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Decrease the Number of Glovebox Glove Breaches and Failures

Jackie Hurtle

12/20/2013

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This process improvement project is designed to decrease the number of glovebox glove breaches and failures at Technical Area (TA) 55 - Plutonium Facility (PF) 4 at Los Alamos National Laboratory (LANL) to protect the worker; reduce exposures to, and releases of, radioactive materials; address contamination and radiation protection concerns; and support LANL's mission in plutonium products.

Introduction

Los Alamos National Laboratory (LANL) is committed to the protection of the workers, public, and environment while performing work and uses gloveboxes as engineered controls to protect workers from exposure to hazardous materials while performing plutonium operations. Glovebox gloves are a weak link in the engineered controls and are a major cause of radiation contamination events which can result in potential worker exposure and localized contamination making operational areas off-limits and putting programmatic work on hold. Each day of lost opportunity at Technical Area (TA) 55, Plutonium Facility (PF) 4 is estimated at \$1.36 million.

Between July 2011 and June 2013, TA-55-PF-4 had 65 glovebox glove breaches and failures with an average of 2.7 per month.

The glovebox work follows the five step safety process promoted at LANL with a decision diamond interjected for whether or not a glove breach or failure event occurred in the course of performing glovebox work. In the event that no glove breach or failure is detected, there is an additional decision for whether or not contamination is detected. In the event that contamination is detected, the possibility for a glove breach or failure event is revisited.

The potential factors that surfaced in the cause and effect tools were narrowed to the following list:

- Housekeeping in the glovebox
- Evaluating the glove inspection and deciding to change the glove
- Glove fit
- Glove selection tailored to the process and operator
- Glove tracking data (for prescribed glove change)
- Process specific guidance for when to change gloves related to glove use
- The planning process to change gloves
- Managing sharps
- Latent sharps program
- Mentoring, On-the-Job Training (OJT), cold lab practice, qualified trainer
- Human performance
- Engineered controls: Perceived value of change is less than the perceived value of using the legacy equipment and tools
- Cost estimates for glovebox design and engineered controls are not realistic
- Communication between the design team and the glovebox users is lacking and the equipment in the glovebox suffers from poor engineering

Targeted solutions were identified after four probable causes were confirmed. These causes include the following:

- Failure to identify latent sharps (inadequate identification of hazards)
- Improper glove fit and selection
- Inadequate use of engineered controls

- Lack of timely glove change

Benefits are realized as the number of glove events decline. This study offers suggestions for influencing the factors that contribute to glove events. With each glove event prevented, LANL saves an average of \$23K on the waste disposal and labor associated with the investigation, mitigation, and reporting. Additional savings are expected from the increased productivity of the facility.

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Project Acronym List

ADESH	Associate Directorate (Director) of Environment, Safety, Health
AP	Administrative Procedure
B	Basic
CCS	Computer, Computational, and Statistical Sciences
CMRR	Chemistry and Metallurgy Research Replacement facility
COPQ	Cost of Poor Quality
CY	Calendar Year
DET	Detection
Div	Division
DO	Division Office
DOE	Department of Energy
DOP	Detailed Operating Procedure
DP	TA-21 Disposal of Plutonium site
DSESH	Deployed Services Environment, Safety, Health
E	Excitement
ES	Engineering Services
ESR	Engineering Service Request
FLM	First Line Manager
FMEA	Failure Mode and Effects Analysis
FOD	Facility Operations Division (Director)
FSR	Facility Service Request
GB	Glovebox
GGI	Glovebox Glove Integrity
HEPA	High-Efficiency Particulate Air
HF	Hydrofluoric Acid
IPOD	Integrated Plan of the Day
LAFO	Los Alamos Field Office
LANL	Los Alamos National Laboratory
LANS	Los Alamos National Security
LED	Light-emitting diode
LSS	Lean Six Sigma
MET	Manufacturing Engineering and Technology
mil	One thousandth of an inch
MOV	Management Observation and Verification
MRB	Management Review Board
mrem	millirem
MSA	Measurement System Analysis
NCO	Nuclear Component Operations
NDA	Non-Destructive Assay
NPI	Nuclear Process Infrastructure

OCC	Occurrence
OJT	On-the-Job Training
OPS	Operations
ORS	Operations Responsible Supervisor
P	Performance
PF	Plutonium Facility
PFITS	Performance Feedback and Improvement Tracking System
PIP	Process Improvement Project
PPE	Personal Protective Equipment
Pu	Plutonium
QA	Quality Assurance
RCT	Radiation Control Technician
RP	Radiation Protection
RPN	Risk Priority Number
RPO	Radiation Protection Observation
RUMBA	Reasonable, Understandable, Measureable, Believable, and Achievable
SEV	Severity
SIPOC	Suppliers, Inputs, Process, Outputs, Customers
TA	Technical Area
TLD	Thermoluminescent Dosimetry (Dosimeter)
TRU	Transuranic
WSST	Worker Safety & Security Team

Define

The define phase for this Process Improvement Project (PIP) involved extensive team interaction to validate and support the business case, problem statement and objective. The team developed a high level process map, a process SIPOC (describes Suppliers, Inputs, Process, Outputs, and Customers), a detailed process map, and validated the data collection system with a measurement system analysis data audit.

Business Impact

Los Alamos National Laboratory (LANL) operations take place at 20 active nuclear facilities and more than 170 buildings with radiological hazards including Technical Area (TA) 55 - Plutonium Facility (PF) 4. Between July 2011 and September 2012, LANL had 118 personal protective equipment (PPE) contamination events with an average of 7.9 events per month with 79% of them originating at TA-55-PF-4. In addition, 21% of the LANL-wide PPE contamination events were due to glove breaches and failures at TA-55-PF-4.

LANL is committed to the protection of the workers, public, and environment while performing work and uses gloveboxes as engineered controls to protect from exposure to hazardous materials while performing plutonium operations. Glovebox gloves are a weak link in the engineered controls and are a major cause of contamination events which can result in potential worker exposure and localized contamination making operational areas off-limits and putting programmatic work on hold. Each day of lost opportunity at TA-55-PF-4 is estimated at \$1.36 million.

Problem Statement

Between July 2011 and June 2013, TA-55-PF-4 had 65 glovebox glove breaches and failures with an average of 2.7 per month. The current target is one or less per month averaged over time. With 2.7 glovebox glove breaches and failures per month, the cost of poor quality (COPQ) is \$1.5 million per year.

Cost of Poor Quality

Money spent on activities that could have been avoided is categorized as COPQ. The total COPQ includes the cost to investigate and mitigate common glove breaches and failures and the loss of facility productivity and is estimated at \$1.5 million per year. In addition, there are nonmonetary impacts. Each element of the COPQ is described below.

Investigation and Mitigation

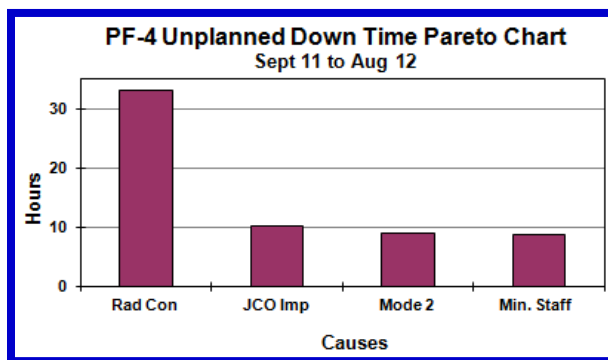
The cost of investigation and mitigation for common glove breach and failure events is \$758K per year. This estimate is based on an average of 2.7 common glove breach and failure events per month and an average cost of \$23K per event for the waste disposal and the labor associated with the investigation, mitigation, and reporting. This COPQ is associated with B2 savings, used to produce more of the same scope type. The specific resources and rates are summarized in the following table.

Stage	Activity	Resources	Participants	Hours	Unburd Rate (\$/hr)	Unburd Cost (\$)	Basis
Investigation	Field investigation	RCT	2	4	\$ 60	\$ 480	Per Event
		GGI Staff	1	8	\$ 98	\$ 784	Per Event
	Management critique	RCT	2	1	\$ 60	\$ 120	Per Event
		Manager	10	1	\$ 144	\$ 1,440	Per Event
		Engineer	5	1	\$ 72	\$ 360	Per Event
Mitigation	Glove Replacement	Operator	4	1	\$ 60	\$ 240	Per Event
		FLM RP Manager 1	1	1	\$ 72	\$ 72	Per Event
		Manufacturing Manager 3	1	0.5	\$ 97	\$ 49	Per Event
		RCT	1	1	\$ 60	\$ 60	Per Event
		New glove	1	-	\$ 400	\$ 400	Per glove
	Work Document Preparation	Operator	2	1	\$ 60	\$ 120	Per Event
		FLM RP manager 1	1	1	\$ 72	\$ 72	Per Event
		Team Leader manager 2	1	1	\$ 95	\$ 95	Per Event
		RCT	1	1	\$ 60	\$ 60	Per Event
	Glove Forensics	Scientist	1	10	\$ 132	\$ 1,320	1/4 Events
	Decontamination	Operator	2	2	\$ 60	\$ 240	Per Event
		RCT	1	2	\$ 60	\$ 120	Per Event
Reporting	Log critique and PFITS actions	Professional	1	1	\$ 72	\$ 72	Per Event
	Entry in RPO system	RCT	1	2.5	\$ 60	\$ 150	Per Event
Waste Disposal	Activity	Resources	Volume	Unit	Rate (\$/unit)	Cost (\$)	Basis
	Liquid waste disposal	Low Level Waste	10	gal	\$ -	\$ -	Per Event
	Solid waste disposal	Low Level Waste	1	M ³	\$ 17,582	\$ 17,582	Per Event
	Mixed TRU waste disposal	TRU Waste	0.208	M ³	\$ 17,500	\$ 17,500	Per Year

Common event \$ 22,846 (2.7/mo)
Periodic cost \$ 17,500
Cost per year \$ 757,694

Facility Productivity

At TA-55-PF-4, a day's loss of productivity is estimated to cost \$1.36 million. Actual facility availability is estimated at 96.38 %¹ based on the first six months of 2013. Based on facility operations data for September 2011 to August 2012, approximately 50% of the unplanned down time is attributed to radioactive contamination. The supporting graph from the operations center is shown below.



From the Radiation Protection Observation (RPO) system, for all of the radioactivity contamination events at TA-55-PF-4, 15% of the observations involve glovebox glove breaches and failures. With these estimates, the COPQ for TA-55-PF-4 down time associated with glove breach and failure events is estimated to be \$716K per year assuming 195 annual work days (the weekly schedule is Monday through Thursday). The calculation for the COPQ of \$716K/yr, associated with B2 savings, is shown below.

TA-55-PF-4 COPQ: $\$1.36 \text{ million/day} * 195 \text{ days/yr} * (100 - 96.38 \%) * 0.5 * 0.15 = \716K/yr

Additional Impacts

In addition, there is COPQ for the nonmonetary impacts associated with the public perception of poor performance, loss of confidence from stakeholders, and potential exposure of workers. These nonmonetary losses are reported as B3. B3 is defined as an improvement that generates benefits that cannot be described in monetary terms.

Project Objective

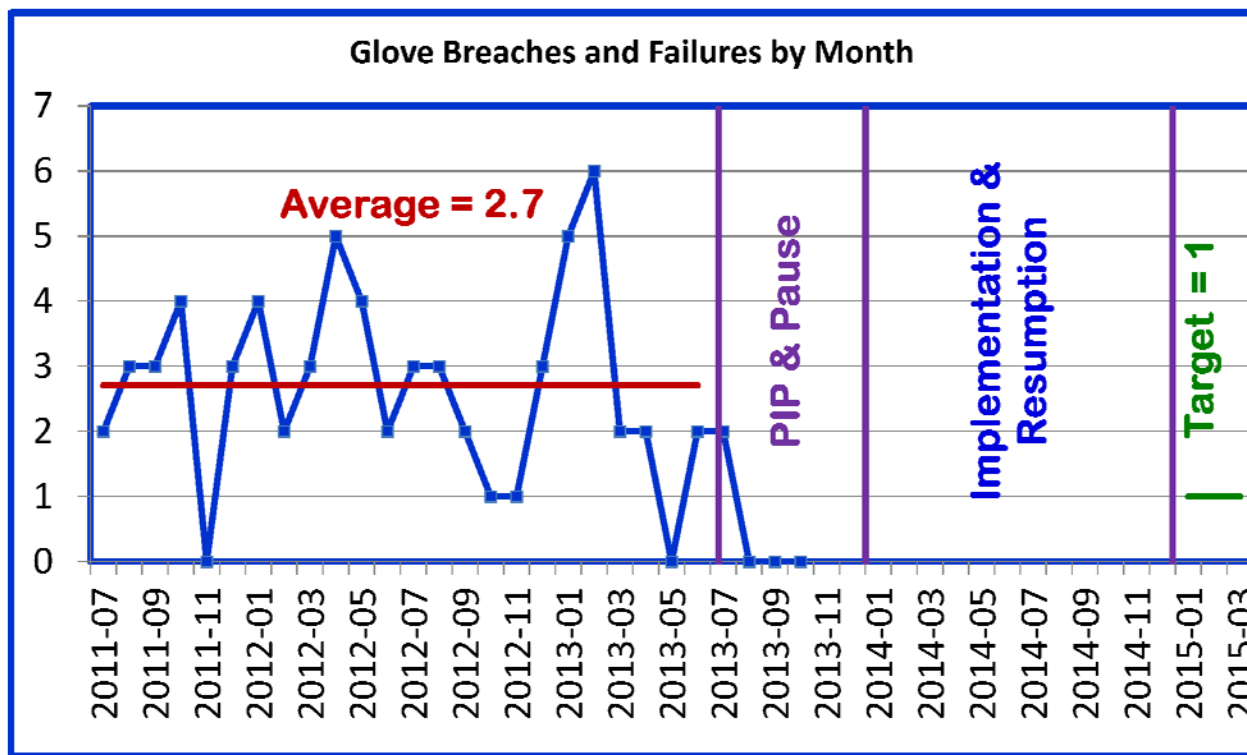
The project objective is to reduce the number of glovebox glove breaches and failures at TA-55-PF-4 by 63% from a baseline of an average of 2.7 events per month to one or less per month averaged over time. Upon implementation of improvements identified in this report, future savings are estimated to be \$929K per year.

The target was set as an aggressive goal while recognizing that glove breaches and failures will not be completely preventable.

¹ Memo from Chuck Tesch, TA-55-OPS, dated July 1, 2013, with subject: TA-55-PF-4 Facility Availability Report June 2013.

Primary Metric

The primary metric is the number of glove breach and failure events per month as reported in the RPO system and shown in the graph below. The project baseline is an average of 2.7 events per month and the target is one or less glove breach and failure events per month averaged over time.

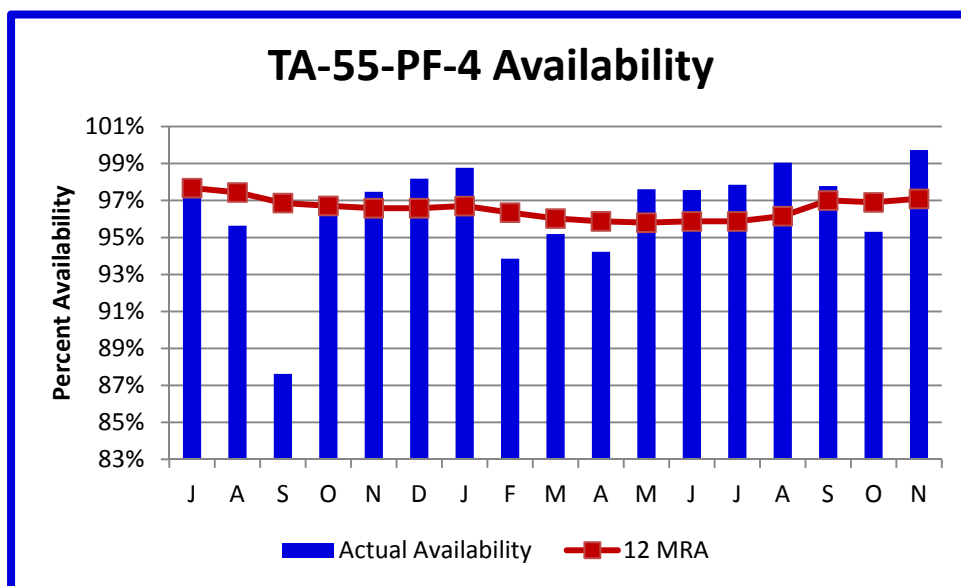


On June 27, 2013, the laboratory director issued a programmatic pause in operations for TA-55-PF-4. Therefore, the primary metric reflects a period of resumption that will overlap with the period of implementation of solutions. A generous period of time will be required before the facility returns to normal operating equilibrium.

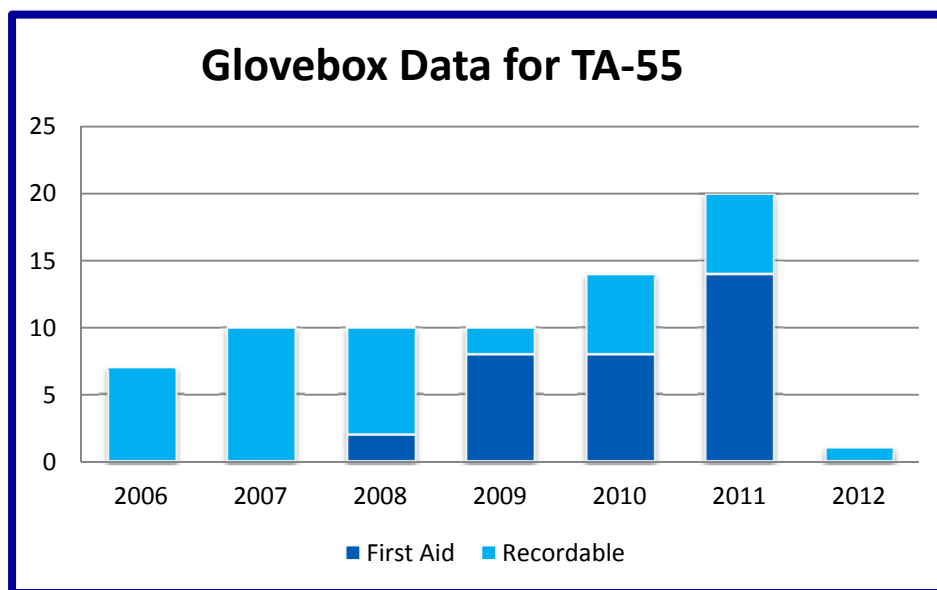
Secondary Metric

There are multiple secondary metrics for this project. The project initially started with the facility availability as a secondary metric as a surrogate for facility productivity. As the project developed, additional secondary metrics were selected to ensure that measures recommended from this project do not compromise ergonomic safety and radioactive dose protection for the worker. A final secondary metric was selected to ensure that gloves are not changed unnecessarily and prematurely as a result of this study.

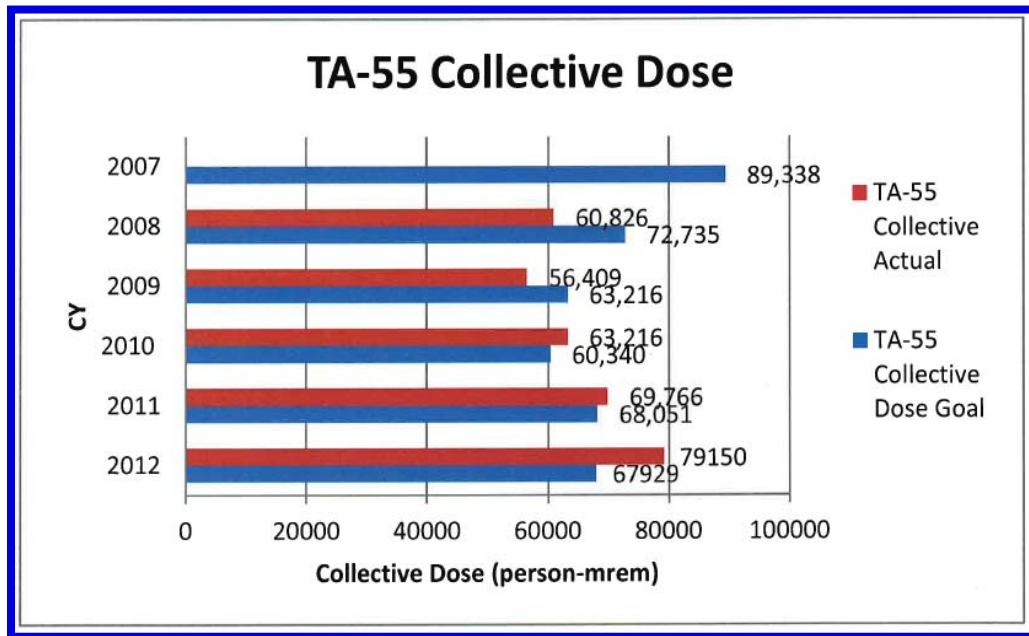
The TA-55-PF-4 facility availability chart is shown below. The chart shows the monthly availability and the 12 month rolling average which generally hovers around 97% between July 2012 and November 2013.



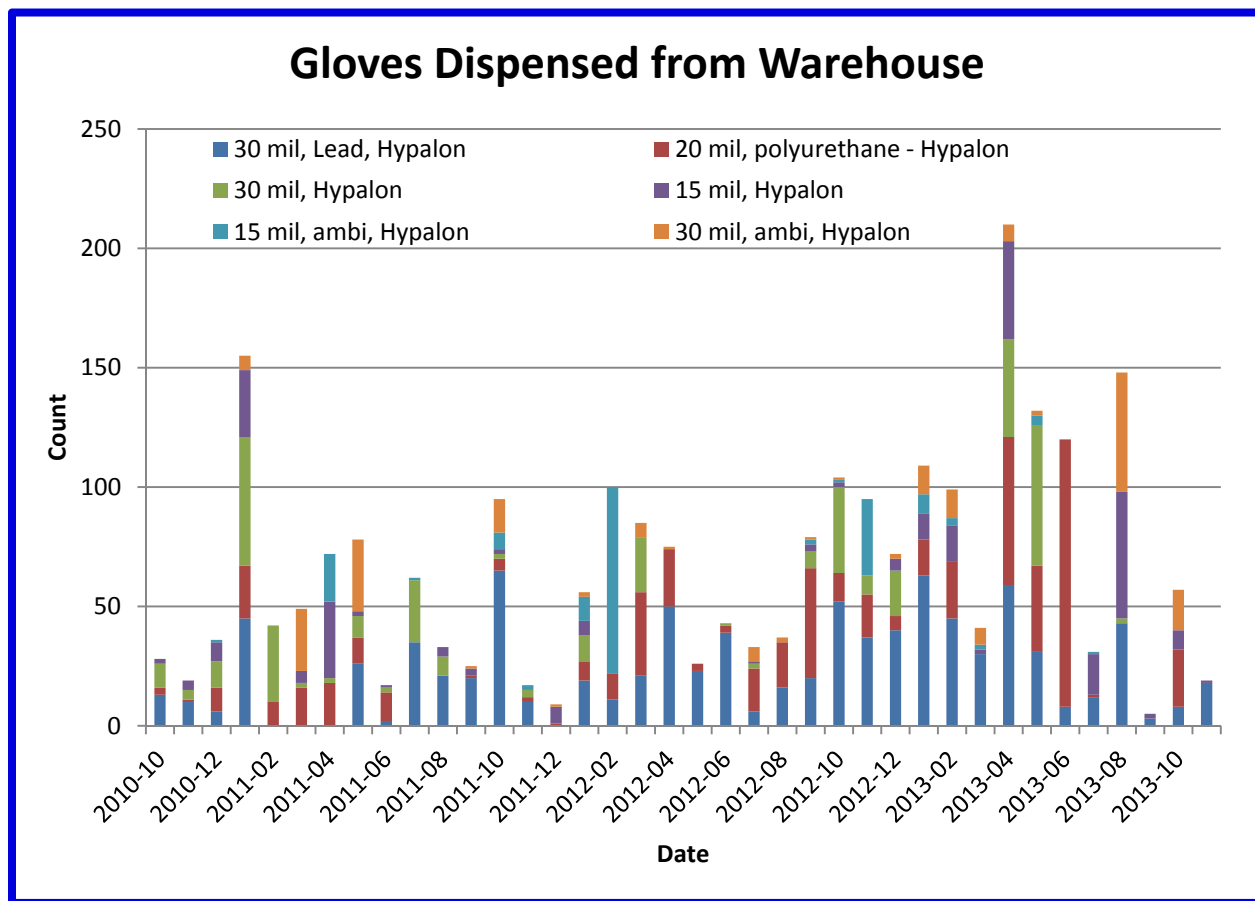
The TA-55 glovebox chart for first aid and recordable cases is shown below. The chart shows that 2012 was a remarkable year with only one recordable case.



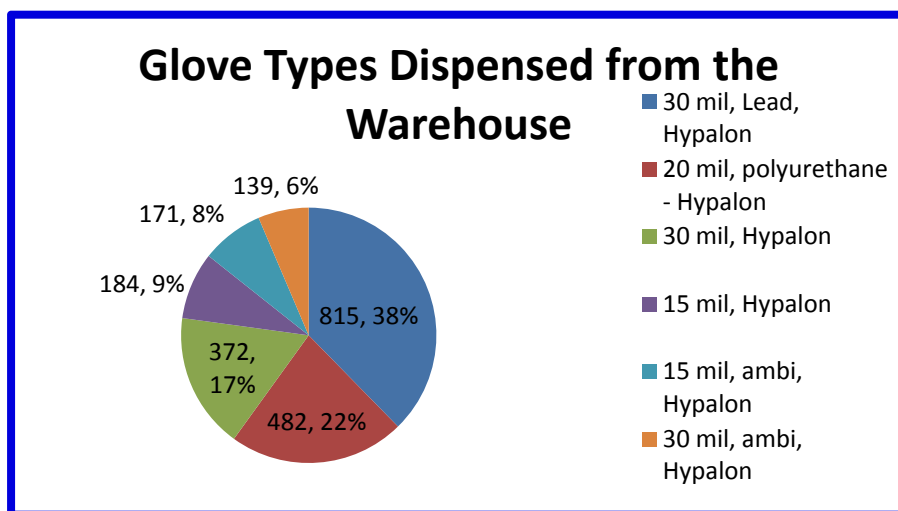
The TA-55 collective dose chart is shown below. For the past three years, the actual doses have exceeded the dose goals. The 2013 dose goal is 61,140 person-mrem.



The chart for the gloves dispensed from the warehouse to TA-55-PF-4 is shown below. Gloves are dispensed in pairs.



The glove demographics are further broken down in the pie chart below. The predominant glove used, 38%, is 30 mil thick Hypalon with lead. Sixty one percent of the gloves are 30 mil thick. Twenty-two percent are 20 mil thick. Seventeen percent are 15 mil thick. Fourteen percent of the gloves are ambidextrous.



Measurement System Analysis

Several measurement system analysis (MSA) audit checks were performed to evaluate the data associated with the primary metric for this project. The checks focused on reviewing RPO entries for inappropriate and missing glove breach and failure flags. The audit also involved checking other logs for glove breaches and failures for events missing from the RPO system.

All RPOs from July 2011 through June 2013 were included in the checks for the MSA. Prior to the MSA, the primary metric included 52 glove breach and failure events. As a result of the MSA checks, 13 additional RPOs were added. The binomial spreadsheet, shown below, was used to calculate the error for 52 units with 13 RPO defects. The nominal error is 25% with an upper failure rate of 38.9%.

95% Confidence Intervals for de		
Confidence -->	0.95	
Units -->	52	
Opportunities -->	1	
TOP's -->	52	
Defects -->	13	
	p(d)	Percent
Upper Limit on Failure Rate	0.3895	38.9%
Nominal Value	0.25	25.0%
Lower Limit on Failure Rate	0.1403	14.0%

The binomial spreadsheet was also used to calculate the error for 65 units, including the original 52 and the corrected 13, with no RPO defects. The nominal error was reduced to 0% with an upper failure rate of 4.5%. The results are shown below.

95% Confidence Intervals for de		
Confidence -->	0.95	
Units -->	65	
Opportunities -->	1	
TOP's -->	65	
Defects -->	0	
	p(d)	Percent
Upper Limit on Failure Rate	0.045	4.5%
Nominal Value	0	0.0%
Lower Limit on Failure Rate	0	0.0%

All of the RPOs flagged for glove breaches and failures provided evidence for the classification. In other words, none of the RPOs were found to be classified erroneously as glove breach or failure events. The graph for the primary metric and the other sections of this report are based on updated RPO numbers.

Audit checks also verified that all of the TA-55 critiques logged from January 2011 to June 2013 and classified as glove breach and failure events were captured in the RPO system. Similar checks of the glovebox safety program data were performed with similar results observed. As a result, there is no evidence that glove breach and failure events are missing from the RPO system.

The Radiation Protection Division was consulted in the course of this measurement system analysis. In response, they corrected the classification of 13 RPOs and issued the following guidance to the Radiation Control Technicians (RCTs) who report and document observations in the RPO system:

- If a glovebox failure is suspected, and there is no other explanation, select glovebox failure as a cause and check the Glovebox Failure criterion.
- If contamination is found in a glovebox glove, and there is no other explanation, change the glove and select glovebox failure as a cause. Indicate that the glove was changed. Check the Glovebox Failure criterion.
- If there is cross-contamination between gloves, there probably was at least one breached glove. If no other source of contamination is found, select glovebox failure as a cause and check the Glovebox Failure criterion.

The TA-55 critique team was consulted in the course of this measurement system analysis. They corrected three critiques that were erroneously classified and reported as glove breach and failure events when they were not. The three critiques include the following:

- RPO 4440 (PFITS 2012-1134)
- RPO 4663 (PFITS 2012-3345)
- RPO 4787 (PFITS 2012-4564)

Additional notes include the fact that neither the TA-55 critiques nor the glovebox safety program data capture all of the glove breach and failure events captured in the RPO system. The RPO system captures events whereas the glovebox safety program data reports per glove involved. Therefore, there are discrepancies between the glovebox glove breach and failure events depending on the source of the report: RPO, critique or glovebox safety program data.

MSA Conclusion

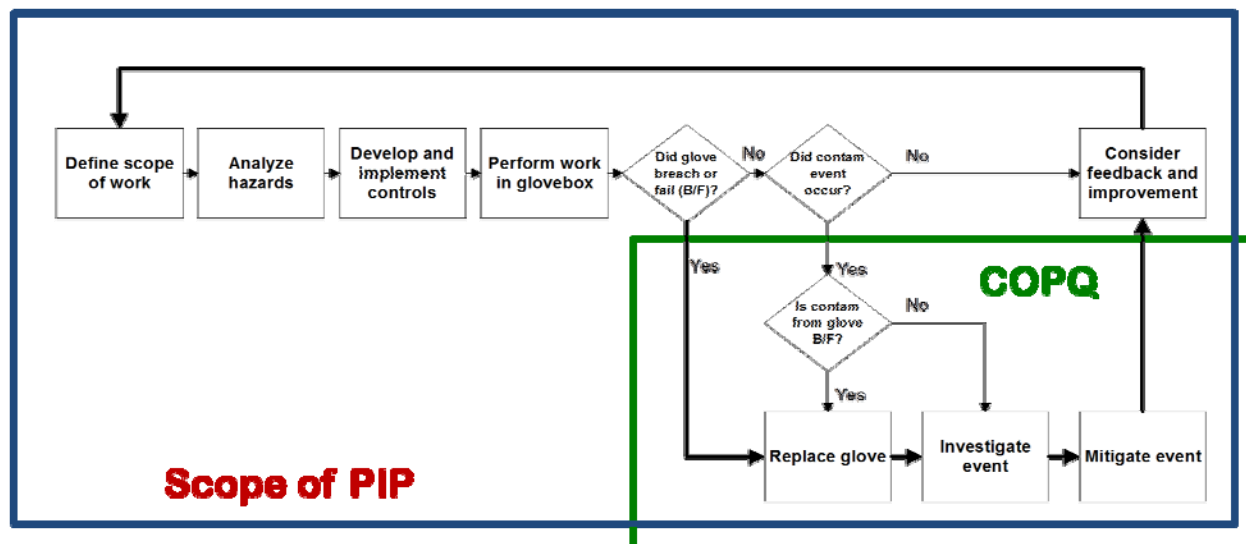
As a result of the MSA, corrections have been made to 13 RPOs and three critiques and additional guidance has been provided to the RCTs for proper reporting of glove breach and failure events in the RPO system. The discrepancies between three tracking systems are now understood. The RPO corrections have been incorporated into the primary metric and reported appropriately in this report. The upper limits on the failures are deemed acceptable. With an upper failure rate of less than 10%, the RPO glove breach and failure event data is deemed acceptable for decision making.

Process Boundaries

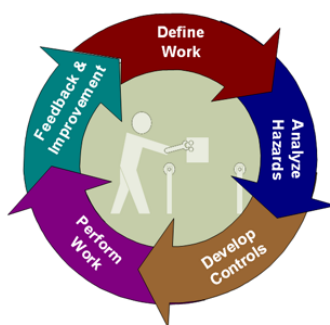
The glovebox glove process was documented in a high level process map, process SIPOC, and detailed process maps. In addition, the glove life cycle is presented in a high level process map. Each is described below.

High Level Process Map

The process is the five step safety process promoted at LANL with a decision diamond interjected for whether or not a glove breach or failure event occurred in the course of glovebox work. In the event that no glove breach or failure is detected, there is a decision for whether or not contamination is detected. In the event that contamination is detected, the possibility for a glove breach or failure event is revisited. Money spent on activities that could have been avoided, including the replacement of a failed or breached glove and the investigation and mitigation of the event, is labeled as COPQ. The high level process map is shown below.



LANL's five step safety icon which serves as the foundation for the high level process map, is presented below.



SIPOC

The high level process map described above is shown in the center of the SIPOC presented below. The SIPOC also includes the suppliers, inputs, outputs and customers for the glovebox glove process. The suppliers include the workers who provide the services and those who receive the services and the managers for both parties. Inputs include the radioactive materials and the equipment and controls associated with their use. Inputs also include the requirements and tools for protecting the workers and

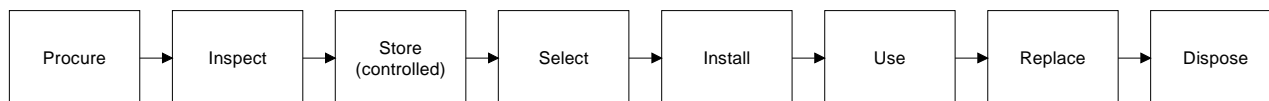
limiting exposure to radioactivity. The outputs are safe workers, programmatic deliverables, waste byproducts, and reporting. Finally, the customers include the workers, managers, recipients of the programmatic deliverables, and oversight organizations. Controls are commensurate with the risks inherent with plutonium work.

Suppliers/ Sources	Inputs/ Drivers	Process	Outputs	Customers/ Stakeholders
Programmatic Glovebox Workers Rad Protection (RP) Workers Responsible Line Managers First Line Managers Facilities Operations Directors Program Customers Associate Directorate for Plutonium Science and Manufacturing Glovebox Safety Committee	Radioactive Materials Gloveboxes Programmatic Equipment Facility Equipment Tools Detection Equipment Dose Limits Facility Rad Protection Programs Dosimetry Glovebox Worker Procedures Integrated Work Documents Radiological Work Permit Personal Protective Equipment Training and Qualification	<pre> graph TD A[Define scope of work] --> B[Analyze hazards] B --> C[Develop and implement controls] C --> D[Perform work in glovebox] D --> E{Did glove breach or fail B/F?} E -- Yes --> F[Replace glove] E -- No --> G{Did contam event occur?} G -- Yes --> H{Is contam from glove B/F?} H -- Yes --> F H -- No --> I[Investigate event] F --> J[Mitigate event] I --> J J --> K[Consider feedback and improvement] K --> A </pre>	Plutonium Products Worker Safety Worker Health Waste Radiation Protection Observations Contamination Events Critiques Rad Exposures	Department of Energy National Nuclear Security Administration Defense Program Los Alamos Field Office Los Alamos National Security, LLC Management Glovebox Workers Responsible Line Managers ADESH Activists Waste Management Coordinators Rad Protection Workers Institutional Radiation Safety Committee

Glove Life Cycle Map

Gloves are produced by two manufacturers on molds specially designed for LANL gloveboxes. Gloves are available in 3 different thicknesses with and without lead layers for dose protection. Left and right handed gloves as well as ambidextrous gloves are available. After gloves are ordered, procured, and received at LANL, they are subject to receipt inspection. Gloves are subject to controlled storage until they are requested for installation in a glovebox. Gloves are used until they are replaced for a variety of

reasons including glove breach or failure. Leaded gloves have to be disposed of as mixed waste. The glove life cycle is shown below.



Detailed Process Map

The detailed process map is included in the appendices. Toward the center of the map is one activity colored purple. This is the single activity in the map that reflects work directly on the plutonium product in a glovebox. In general, all of the activities leading to and following that one activity reflect preparation and hazard control activities. The activities colored yellow reflect activities that could be avoided with the avoidance of a glove breach or failure.

Customer Requirements

The voice of the customer exercise started with the identification of the direct, secondary, and indirect customers; the development of interview questions; and face-to-face customer interviews. The customer demographics are shown below. The table includes the role of the customer and the specific customers interviewed. In addition, the team members responded to the interview questions. No external customers were interviewed.

	Internal			External
Direct	Workers	Floyd Rodriguez	NCO-1	
		Georgette Ayers	NCO-2	
		Vince Garcia	NPI-3	
		Adrian Padilla	NCO-1	
		Diane Spengler	MET-1	
		Kent Kramer	NCO-5	
		Louie Jaramillo	DSESH-TA55	
Secondary	Site Support			Funding sources
	Facility Operations Directors (FODs)	Bob Mason	TA-55-DO	
	Program Manager	Brad Smith	NPI-3	Sponsoring Agencies
		Tim Nelson	NCO-DO	LAFO
		Tony Drypolcher	MET-DO	
Indirect	RP-DIV	Scotty Jones	RP-DO	Activists
	ADESH	Michael Brandt	ADESH	DOE

The detailed results of the customer interviews are included in the appendices. The highest ranking customer requirements for the glovebox glove process are summarized in the table below. In general, the customers of the glovebox glove process need containment and prevention for the spread of contamination. In addition, the customers need safe workers free from ergonomic injuries and with minimal dose.

The following table provides the ranked customer requirements with the associated measures. The table also provides the classification as basic (B), performance (P), or excitement (E), and checks for meeting the reasonable, understandable, measurable, believable, and achievable (RUMBA) criteria. One additional customer requirement, improved process and glovebox design, did not meet the RUMBA criteria because it is not measurable.

Requirement	B, P, E	RUMBA						Measurable	Target (current)	Importance Rank
		R	U	M	B	A	Y/N			
Containment and prevention for spread of contamination	B	√	√	√	√	√	√	Radiation Protection Observations (RPOs)	≤1 glove breach or failure per month	10
Safe workers free from ergonomic injury	B	√	√	√	√	√	√	Recordables	0	8
Improved process and GB design	E	√	√		√	√		ESR	Undefined	7
Safe workers with minimal dose	B	√	√	√	√	√	√	TLD and RP measurements	TA-55 Collective Dose (2013) 61,140 person-mrem	6

For basic requirements, the customer would like the product to meet the requirement and would be upset if the product failed to meet the requirement. For performance requirements, the customer would be pleased for the product to meet the requirement and would be very upset for the product not meeting the requirement. For excitement requirements, the customer would be excited for the product to meet the requirement and would be indifferent if the product did not meet the requirement, since they were not expecting it. This voice of the customer exercise only revealed valid basic requirements.

There is strong alignment between the customer requirements and the internal measures as demonstrated in the table below.

	Importance	Glove Breaches and Failures	Radiation Protection Observations	First Aid and Recordable	TLD and RP measurements
Containment and prevention for spread of contamination	10	P	O		
Safe workers free from ergonomic injury	7			S	
Safe workers with minimal dose	6				S

O = Other metric, P = Primary metric, S = Secondary metric

Define Summary

The PIP team validated the business case, problem statement, and objective for the project with the primary and secondary metrics and input from the customers. In addition, the team developed a high level process map, a process SIPOC, glove lifecycle map, detailed process map, and validated the data collection systems for the primary metric with a measurement system analysis data audit. The project objective is to reduce the number of glovebox glove breaches and failures at TA-55-PF-4 by 63% from a baseline of 2.7 events per month to one or less per month averaged over time after the implementation of improvements identified in this report for a future savings of \$929K per year.

Measure

The team set a solid foundation in the define phase for the transition to the measure phase. A fishbone diagram, a Failure Mode and Effects Analysis (FMEA) spreadsheet, and a capability analysis were all completed. The measure phase culminated with the identification of the factors (possible X list).

Fishbone Diagram

The fishbone diagram was constructed to surface factors contributing to glove breach and failure events and is included in the appendices. The major bones of the diagram include people, measurements, environment, machines, materials, and methods and procedures. After completing the diagram, the team members were asked to identify their top ten issues contributing to glove breach and failure events. The top issues identified by the team were consolidated and evaluated in discussions. The end result of the discussions included a list of the top contributing factors. The top contributing factors are as follows:

- Housekeeping in the glovebox
- Evaluating the glove inspection and deciding to change the glove

- Glove fit includes: dexterity, tightness (issue for big hand), pinches (issue for small hand), thumb position (hand position is a “C” and glove position is a “V”)
- Glove selection tailored to the process and operator
- Glove tracking data (prescribed glove change)
- Process specific guidance for when to change gloves related to glove use
- Managing sharps (perceived inconsistencies in)
- Latent sharps program
- Mentoring, OJT, cold lab practice, qualified trainer
- Human performance
 - Complacency, Awareness, Motivation, Goals and Rewards, Fatigue, Stress
- Engineered controls: Perceived value of change is less than the perceived value of using the legacy equipment

Failure Mode and Effects Analysis

The Failure Mode and Effects Analysis spreadsheet was also constructed to surface factors contributing to glove breach and failure events. The FMEA spreadsheet was completed with a simple custom rating system for the occurrence and detection scores. The team realized that gradation on the severity could not be established because of the risk that all glove breaches and failures could result in internal dose. The entire spreadsheet is shown in the appendices with the custom rating tool. The top ranked factors with scores greater than 800 are presented in the list below.

- Glove box (GB) process (fish)
- Limited glove size available from manufacturer (fish)
- No ability to switch glove for operator (fish)
- Difficult to predict glove demand (fish)
- Extension of glove use (fish)
- Unaware of sharps (fish)
- Line of fire (contact with glove, ex. is cart), (fish)
- Cross functional changes are difficult (fish)
- Machines are not replaced (fish)
- Reuse system (repurpose GB), (fish)
- Arduous process to plan glove change
- Cost estimates are not realistic
- Lack of communication between design team and GB user
- Poor engineering of equipment in GB

The team was quick to realize the connection between the factors that surfaced in the fishbone diagram and the FMEA spreadsheet. The list above indicates if the FMEA factor was previously identified in the fishbone diagram. The following table shows the association for the factors between the two sources.

Fishbone Factor	FMEA Factor
Housekeeping in the glovebox	
Evaluating the glove inspection and deciding to change the glove	GB process

Fishbone Factor	FMEA Factor
Glove fit includes: dexterity, tightness (issue for big hand), pinches (issue for small hand), thumb position (hand position is a "C" and glove position is a "V")	Limited glove size available from manufacturer
Glove selection tailored to the process and operator	No ability to switch glove for operator
Glove tracking data (prescribed glove change)	Difficult to predict glove demand
Process specific guidance for when to change gloves related to glove use	GB process
	Extension of glove use
Managing sharps (perceived inconsistencies in)	
Latent sharps program	Unaware of sharps
Mentoring, OJT, cold lab practice, qualified trainer	Line of fire (contact with glove, ex. is cart)
Human performance	Line of fire (contact with glove, ex. is cart)
Engineered controls: Perceived value of change is less than the perceived value of using the legacy equipment and tools	Cross functional changes are difficult
	Machines are not replaced
	Reuse system (repurpose GB)

The team opted for the terminology established in the fishbone diagram analysis to capture the similar factors from the FMEA spreadsheet. In one case, the engineered controls, the fishbone factor was adjusted to include tools to accurately reflect the factor from the FMEA spreadsheet. The fishbone factors were supplemented with the addition of the following FMEA factors:

- The planning process to change gloves is arduous
- Cost estimates for glovebox design and engineered controls are not realistic
- Communication between the design team and the glovebox users is lacking and the equipment in the glovebox suffers from poor engineering

Capability Analysis

A defect analysis for attribute data associated with the number of glove breach and failure events was performed. The binomial spreadsheet was populated with units for a 24 month period and 20 months with more than one glove breach or failure event per month, the target for this project. The conclusion is that the current process is not able to meet the target of a maximum of one event per month nominally more than 17% of the time. There is a great opportunity for process improvement. The results from the binomial spreadsheet are shown below.

Confidence -->	0.95
Units -->	24
Opportunities -->	1
TOP's -->	24
Defects -->	20

	p(d)	Percent	ppm	Z _{ST}		Defects	
Upper Limit on Failure Rate	0.9526	95.3%	952646	0.00	<= "worst case" =>	22	95%
Nominal Value	0.8333	83.3%	833333	0.00	<= "best estimate"		Confidence
Lower Limit on Failure Rate	0.6262	62.6%	626158	0.00	<= "best case" =>	16	Interval

Measure Conclusions

In the measure phase, the team narrowed the list of potential factors that surfaced in the cause and effect tools including the fishbone diagram and the FMEA spreadsheet. The final list of factors is presented below.

- Housekeeping in the glovebox
- Evaluating the glove inspection and deciding to change the glove
- Glove fit includes: dexterity, tightness (issue for big hand), pinches (issue for small hand), thumb position (hand position is a “C” and glove position is a “V”)
- Glove selection tailored to the process and operator
- Glove tracking data (for prescribed glove change)
- Process specific guidance for when to change gloves related to glove use
- The planning process to change gloves is arduous
- Managing sharps (perceived inconsistencies in)
- Latent sharps program
- Mentoring, OJT, cold lab practice, qualified trainer
- Human performance
- Engineered controls: Perceived value of change is less than the perceived value of using the legacy equipment and tools
- Cost estimates for glovebox design and engineered controls are not realistic
- Communication between the design team and the glovebox users is lacking and the equipment in the glovebox suffers from poor engineering

Analyze

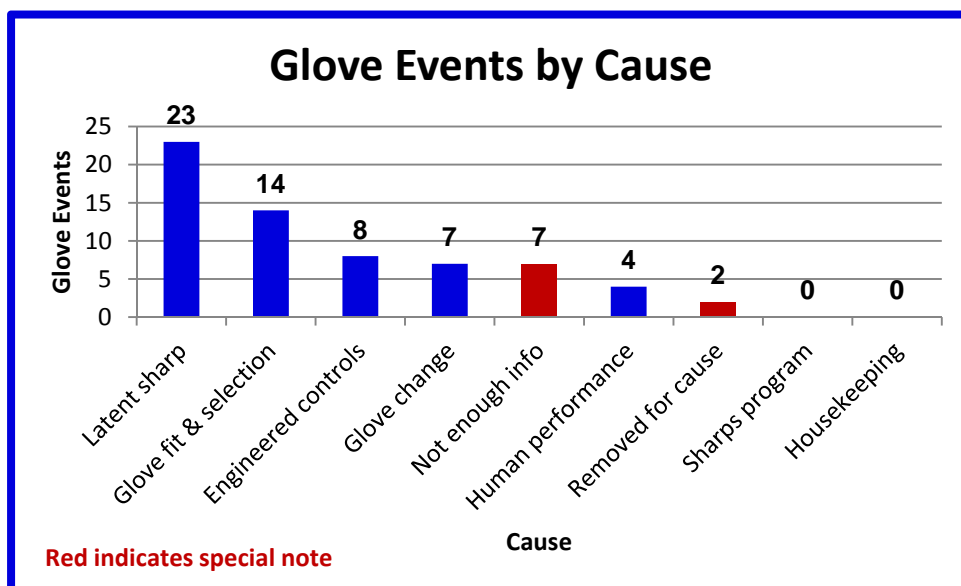
Fourteen potential factors were carried forward from the measure phase into the analyze phase for data analysis. The data analysis started with a review of the 65 glove events documented in the RPO system and progressed to a review of the critique summaries for 27 (42%) of the glove events. In addition, the glovebox glove operators were interviewed when available. The results of the glove event investigations were evaluated in a series of graphical and statistical analysis. To some extent, the potential factors were combined and rolled up to a higher level to align with the information documented and available for the glove events. The potential factors and the associated questions of interest are presented in the table below.

Factor	Practical Question
Housekeeping in the glovebox	Does housekeeping in the glovebox contribute to glove breaches and failures documented in the RPOs?
Glove fit	Does poor glovebox glove fit or selection contribute to glove breaches and failures documented in the RPOs?
Glove selection tailored to the process and operator	

Factor	Practical Question
Glove tracking data (for prescribed glove change)	Does the lack of timely glove change contribute to glove breaches and failures documented in the RPOs?
Evaluating the glove inspection and deciding to change the glove	
Process specific guidance for when to change gloves related to glove use	
The planning process to change gloves is arduous	
Managing sharps (perceived inconsistencies in)	Does the failure to implement and comply with the sharps program contribute to glove breaches and failures documented in the RPOs?
Latent sharps program	Does the failure to recognize latent sharps contribute to glove breaches and failures documented in the RPOs?
Mentoring, OJT, cold lab practice, qualified trainer	Does poor or non-compliant worker performance, mentoring or training contribute to glove breaches and failures documented in the RPOs?
Human performance	
Engineered controls: Perceived value of change is less than the perceived value of using the legacy equipment and tools	Does inadequate use of engineered controls contribute to glove breaches and failures documented in the RPOs?
Cost estimates for glovebox design and engineered controls are not realistic	
Communication between the design team and the glovebox users is lacking and the equipment in the glovebox suffers from poor engineering	

Testing

Each of the 65 glove events was assigned to a primary cause based on the RPO documentation and in some cases the critique information and glovebox operator interviews. The result of this assessment is presented in the chart below, titled Glove Events by Cause.



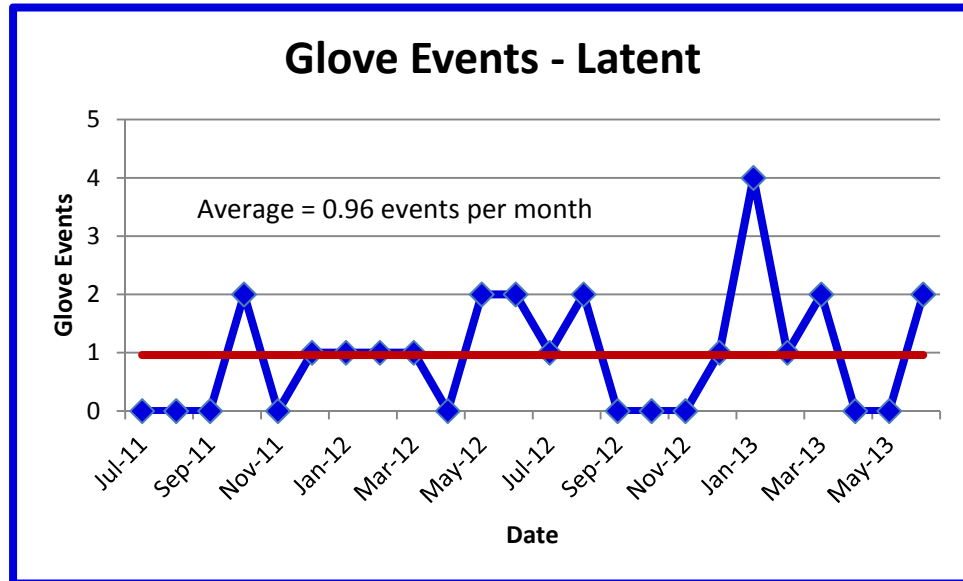
Each cause will be discussed in more detail in the following sections. Seven of the glove events, shown in red above, did not have sufficient information to assign a primary cause and are not discussed further. Two of the glove events, shown in red above, were determined to be truly unique and not informative for the reduction in programmatic glovebox glove events. The two unique glovebox glove events involved a glove bag and a glove associated with a zone 1 filter plenum glovebox. The two unique glove events were isolated for special cause and will not be discussed further.

Does the failure to recognize latent sharps contribute to glove breaches and failures documented in the RPOs?

This question is designed to establish if poor hazard identification and evaluation associated with latent sharps contributes to glove events. Latent conditions are undetected weaknesses or equipment flaws that typically lie dormant.

Graphical Analysis

The previous chart compares the number of glove events caused by latent sharps, 23 events or 35%, from a total of 65 glove events, between July 2011 and June 2013. It appears that latent sharps are contributing to glove events. The following chart shows the number of glove events caused by latent sharps each month for the past two years.



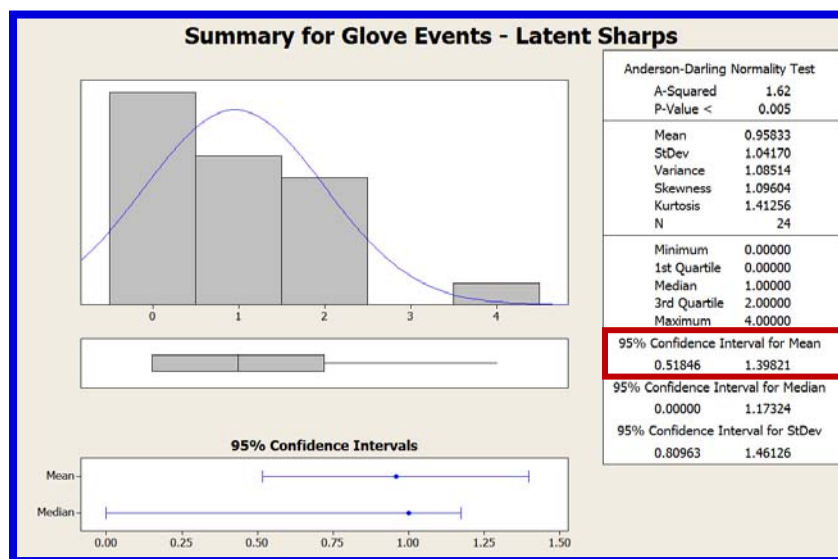
The following provides a list of latent sharps that were cited for the glove events.

- Installing, struggling with, and contacting bolts
- Using tube cutter
- Handling oxidized and/or corroded material, parts, and pieces
- Contacting neutron shield
- Handling jammed transfer cart
- Handling glass that broke
- Handling stainless steel tubing & fittings
- Applying pressure to guillotine door
- Contacting drilling debris
- Handling damaged auger
- Contacting scaffolding or clips
- Using vice grips
- Handling push stick with burr
- Contacting retractable storage table

The bolts; tube cutter; and oxidized and corroded materials, parts and pieces were each associated with more than one glove event in the two year period.

Statistical Analysis

The following chart provides a graphical analysis of the basic statistics for the frequency of glove event RPOs associated with latent sharps that were recorded in each month of the 24 month period from July 2011 to June 2013. On average, there were 0.96 glove events with a 95% confidence that 0.5 to 1.4 glove events occur every month due to latent sharps.



The histogram in the chart above shows the distribution of glove events per month caused by latent sharps. In ten months, there were no breaches or failures. At the other extreme, there was one month with four glove events. There were seven months with one glove event and six months with two events. Below the histogram is the box plot indicating the median of one glove event per month, the inter-quartile range from zero to two, and a complete range from zero to four. The mean is 0.96 glove events per month due to latent sharps.

Conclusion

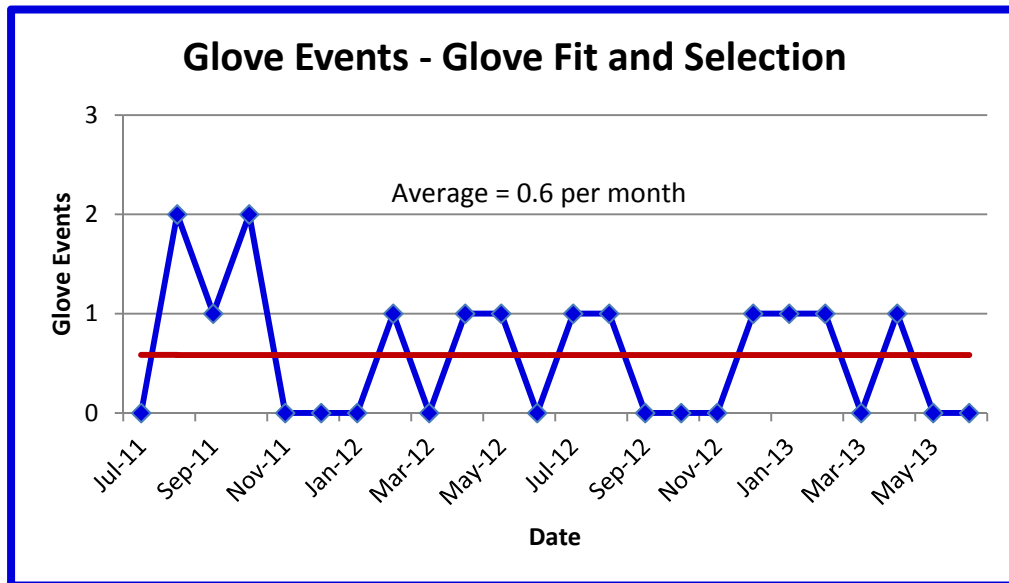
With 0.5 to 1.4 glove events associated with latent sharps every month, there is the opportunity to reduce glove events by identifying and eliminating hazards associated with latent sharps. Approximately one glove event could be eliminated each month.

Does poor glovebox glove fit or selection contribute to glove breaches and failures documented in the RPOs?

This question is designed to establish if ill fitting gloves or poorly selected gloves for the planned activities or hazardous environment are causing glove events reported in the RPO system.

Graphical Analysis

The chart on page 27, Glove Events by Cause, compares the number of glove events related to poor fit and selection from a total of 65 RPOs logged between July 2011 and June 2013. It appears that poor fit and selection is contributing to glove events with 14 out of 65 RPOs, 22%. The following chart shows the number of glove events caused by ill fitting or poorly selected gloves each month for the past two years.

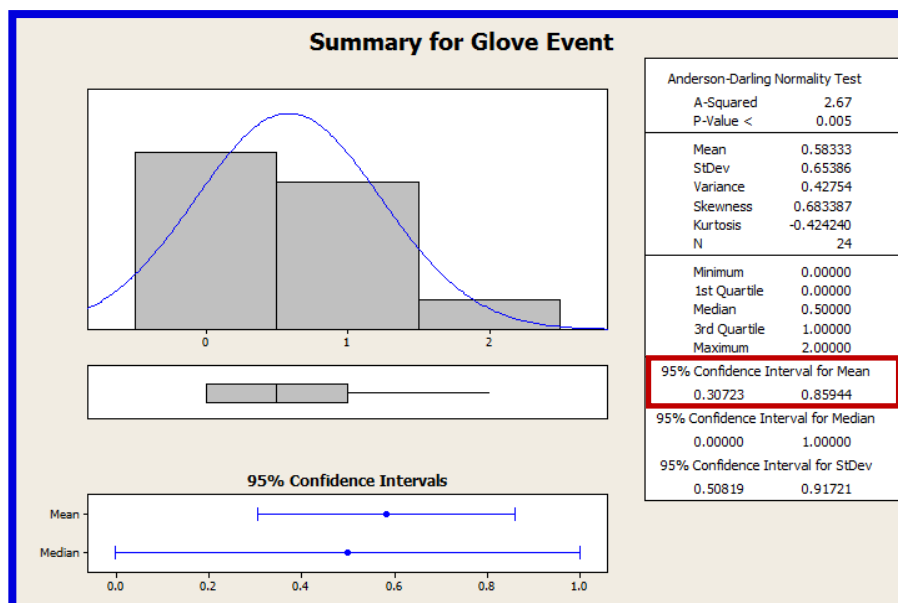


The glove events associated with fit and selection were described with the following information about the opening type and location.

Opening Type	Opening Location
Breach	Web of Thumb
Cut	Palm
Pinch	Finger (index)
Pinch	Finger (index)
Pinhole	Finger (middle)
Pinhole	Palm
Pinhole	Palm
Pinhole	Pinkie
Pinhole	Thumb
Pinhole	Thumb
Pinhole	Upper Arm
Pinhole	Upper Arm
Tear	Forearm

Statistical Analysis

The following chart provides a graphical analysis of the basic statistics for the frequency of glove events associated with ill fitting or poorly selected gloves that were recorded in each month of the 24 month period from July 2011 to June 2013. On average there were 0.58 glove events per month. In addition, there is a 95% confidence that up to 0.9 glove events associated with fit and selection occur every month.



Conclusion

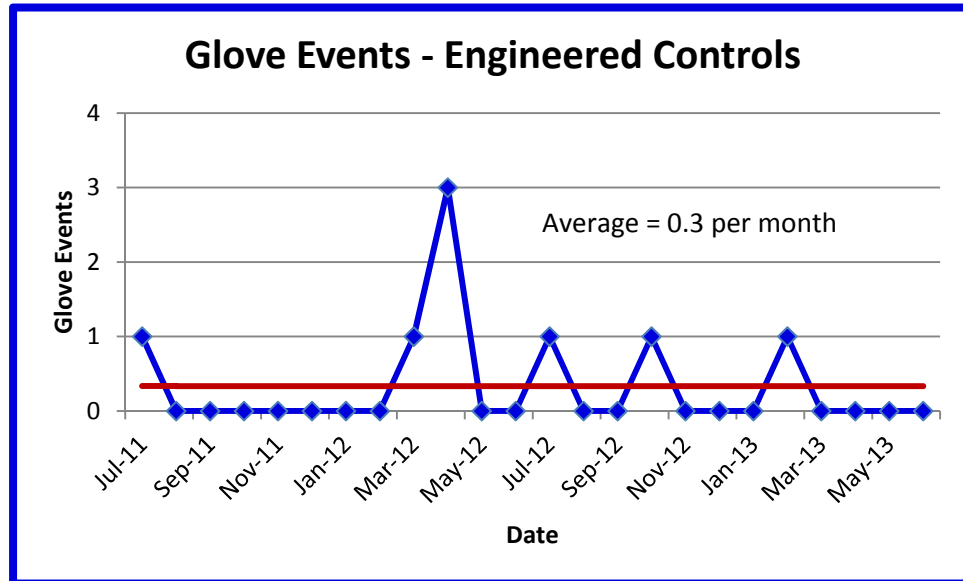
With up to 0.9 glove events associated with glove fit and selection every month and an average of 0.58 glove events per month; there is the opportunity to reduce glove events by addressing glove fit and selection. Approximately one glove event could be eliminated every two months.

Does inadequate use of engineered controls contribute to glove breaches and failures documented in the RPOs?

This question is designed to establish if the use of legacy systems or poorly designed equipment, which could be improved with engineered controls, are causing glove events reportable in the RPO system.

Graphical Analysis

The chart on page 27, Glove Events by Cause, compares the number of glove events related to inadequate use of engineered controls logged between July 2011 and June 2013. It appears that inadequate engineered controls are contributing to glove events with 8 out of 65 RPOs, 12%. The following chart shows the number of glove events caused by inadequate engineered controls each month for the past two years.

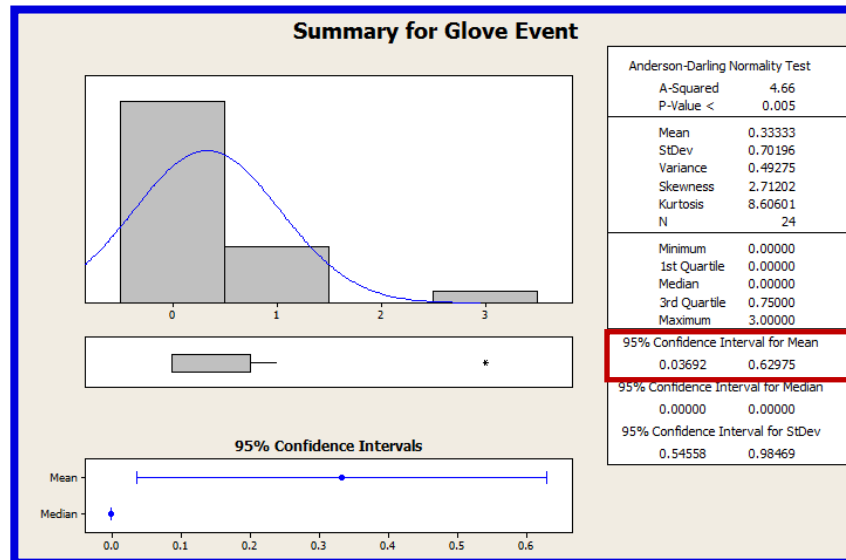


The types of engineered controls which could have prevented glove events in the past 2 years include the following:

- Improved trolley (cart, tray, bucket)
- Method to break samples from epoxy mold
- Shield for falling objects
- Easier application of tape
- Prevention of ejected debris

Statistical Analysis

The following chart provides a graphical analysis of the basic statistics for the frequency of glove events associated with inadequate engineered controls that were recorded in each month of the 24 month period from July 2011 to June 2013. On average there were 0.3 glove events per month. In addition, there is a 95% confidence that up to 0.6 gloves events associated with inadequate engineered controls occur every month.



Conclusion

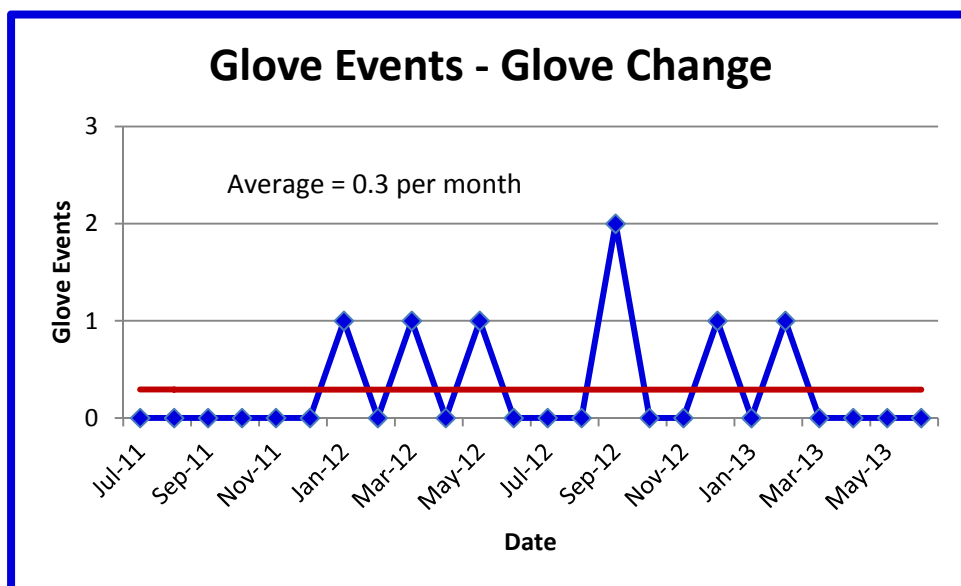
With up to 0.6 glove events every month and an average of 0.3 glove events per month; there is the opportunity to reduce glove events by improving and introducing engineered controls. Approximately one glove event could be eliminated every 3 months.

Does the lack of timely glove change contribute to glove breaches and failures documented in the RPOs?

This question is designed to establish if the lack of a timely glove change due to a failure in the glove inspection and the resulting decision to change the glove, the lack of glove tracking and prescribed change frequency, the absence of process specific guidance for glove changes, or the arduous planning process to change gloves are causing glove events reportable in the RPO system.

Graphical Analysis

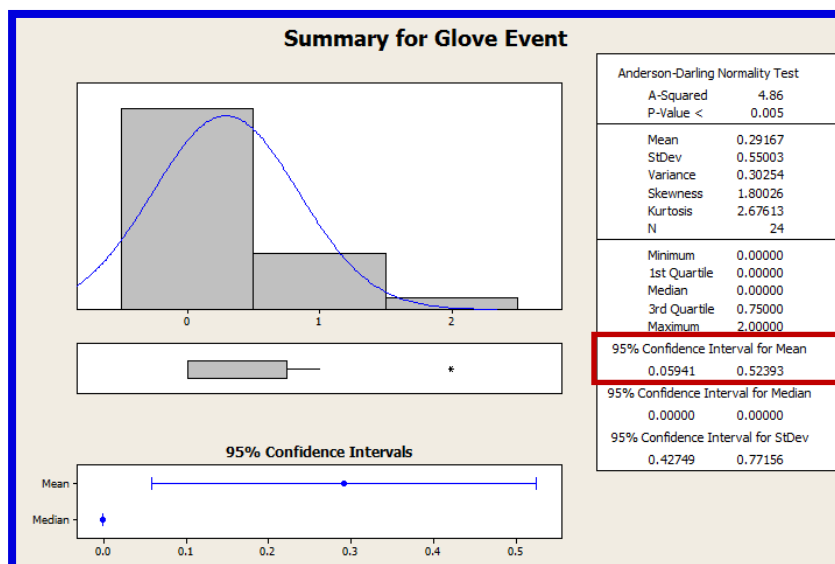
The chart on page 27, Glove Events by Cause, compares the number of glove events related to the lack of timely glove change logged between July 2011 and June 2013. It appears that the lack of timely glove change is contributing to glove events with 7 out of 65 RPOs, 11%. The following chart shows the number of glove events per month for the past two years due to untimely glove changes.



The glove conditions that were reported with glove events classified as caused by untimely glove change include brittle, weak spot, blister, past expiration, worn, and creased.

Statistical Analysis

The following chart provides a graphical analysis of the basic statistics for the frequency of glove events associated with untimely glove changes that were recorded in each month of the 24 month period from July 2011 to June 2013. On average there were 0.3 glove events per month. In addition, there is a 95% confidence that up to 0.5 gloves events associated with untimely glove change occur every month.



Conclusion

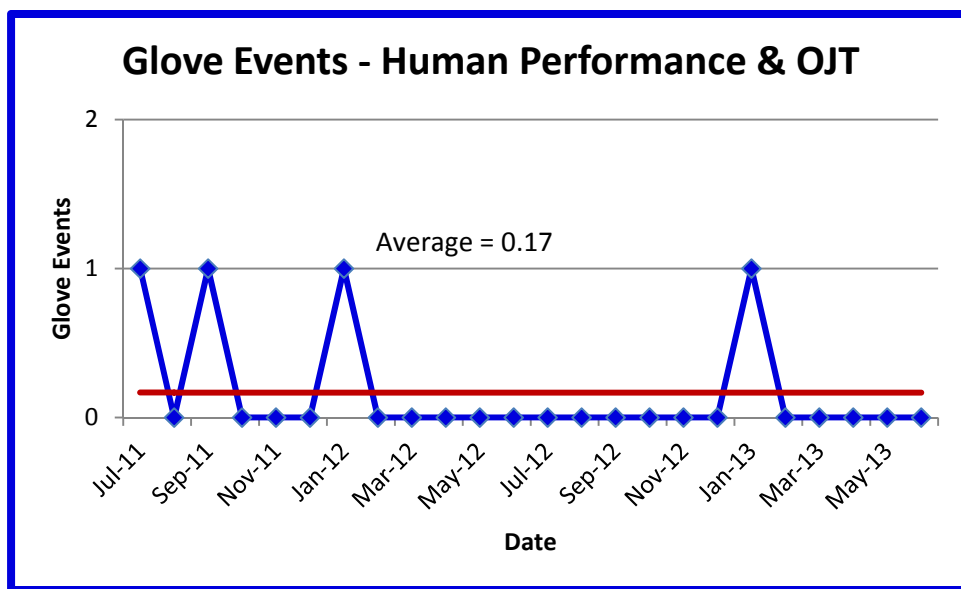
With up to one glove event every two months and an average of 0.3 glove events per month; there is the opportunity to reduce glove events by addressing the timeliness of glove changes. Approximately one glove event could be eliminated every 3 months.

Does poor or non-compliant worker performance, mentoring or training contribute to glove breaches and failures documented in the RPOs?

This question is designed to establish if glove events are a result of poor glovebox operator performance or a break down in the training and mentoring.

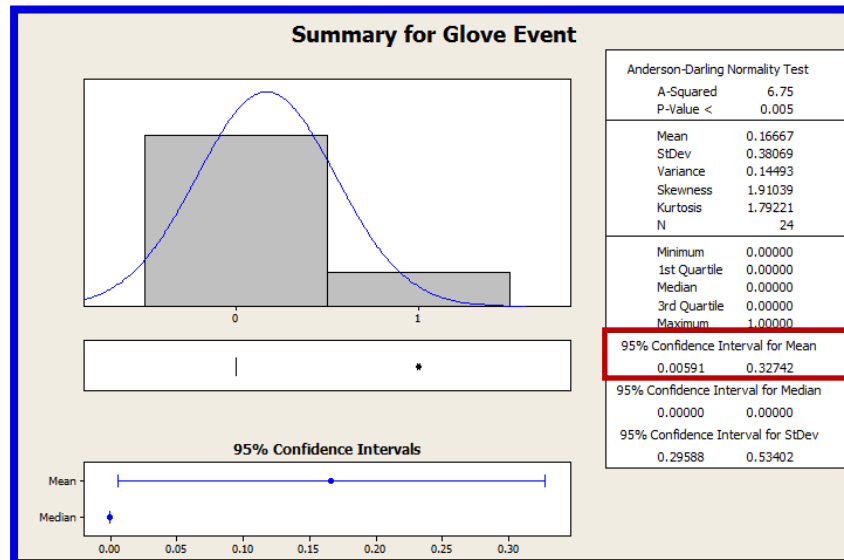
Graphical Analysis

The chart on page 27, Glove Events by Cause, compares the number of glove events related to human performance, training and mentoring from a total of 65 RPOs logged between July 2011 and June 2013. It appears that human performance, training and mentoring are contributing to a minor degree to glove events with 4 out of 65 RPOs, 6%. The following chart shows the number of glove events, attributed to this cause, by month for the past two years.



Statistical Analysis

The following chart provides a graphical analysis of the basic statistics for the frequency of glove events associated with operator performance, training, and mentoring that were recorded in each month of the 24 month period from July 2011 to June 2013. On average there were 0.17 events per months with a 95% confidence that up to 0.3 glove events associated with human performance, training, and mentoring occur every month.



Conclusion

With up to one glove event associated with human performance, training, and mentoring, every three months and an average of one glove event every 6 months; there is little opportunity to reduce glove events by addressing the issues.

Does the failure to implement and comply with the sharps program contribute to glove breaches and failures documented in the RPOs?

This question is designed to establish if acknowledged sharps used in the course of operations are causing glove events reportable in the RPO system.

Graphical Analysis

As demonstrated in the chart on page 27, Glove Events by Cause, none of the 65 RPOs logged between July 2011 and June 2013 indicate that the glove event was caused by the failure to implement or comply with the sharps program.

Conclusion

It appears that the failure to implement and comply with the sharps program is not contributing to glove events. There is minimal opportunity to reduce glove events by addressing the issues. The administrative procedure, TA55 Glovebox Safety Program – Sharps and Latent Sharps Management, describing the sharps program is the same procedure that describes the latent sharps program. The discrepancy in the management of sharps and latent sharps appears to be the hazards identification process for the latent sharps.

Does housekeeping in the glovebox contribute to glove breaches and failures documented in the RPOs?

This question is designed to establish if poor housekeeping or glovebox clutter contributes to glove events reportable in the RPO system.

Graphical Analysis

As demonstrated in the chart on page 27, Glove Events by Cause, none of the 65 RPOs logged between July 2011 and June 2013 indicate that the glove event was caused by poor housekeeping.

Conclusion

It appears that glovebox housekeeping is not contributing to glove events. There is minimal opportunity to reduce glove events by addressing the issues.

Analyze Results

From the graphical analysis and basic statistics, four probable causes were confirmed and they include the following:

- Failure to identify latent sharps (inadequate identification of hazards)
- Improper glove fit and selection
- Inadequate use of engineered controls
- Lack of timely glove change

In addition, three causes were eliminated including human performance and training, non-compliance with the sharps program, and glovebox housekeeping.

In general, factors with the greatest impact on glove events and associated with approximately one or more RPOs every three months will be considered further. The four probable causes that were confirmed will advance to the improve phase for the identification of solutions. With effective solutions targeted at the four probable causes, there is the opportunity to eliminate approximately two glove events per month.

Improve

The improve phase targeted solutions for the four probable causes confirmed in the analyze phase plus best practices.

Improve Solutions

The project team participated in a brainstorming effort targeting solutions for the confirmed causes. The identified solutions are described in the following sections.

Best Practices

The project team recommended regular and standardized investigation of glove events to further characterize the cause of the events. The subject gloves have to be retained to allow for examination. Too many times the gloves are disposed of as soon as they are changed and therefore are not available for examination. A complete list of focus areas to be explored after each glove event needs to be documented. Criteria for when microscopic analysis of gloves should be performed needs to be established and documented. In addition, funding for microscopic analysis needs to be communicated to the TA-55 community. The investigation results need to be documented and maintained for future trending. Trends need to be identified, shared and communicated to the TA-55 community.

Greater attention needs to be applied to ensure the implementation and execution of corrective actions identified during critiques and after investigations to prevent future glove events.

Latent Sharps

All glovebox processes need to be screened for latent sharps. The process documentation in TA55-AP-120, TA55 Glovebox Safety Program - Shards and Latent Sharps Management, addresses the requirements for work releases, tools and equipment location, marking glovebox sharps, and sharps awareness but it does not cover recommendations for the identification and evaluation of latent sharps. Improvements can be made to the current process and documentation. Members of the Glovebox Safety Program use cheesecloth to identify latent sharps as part of glove event investigations. The same cheesecloth evaluation should be used to identify the latent sharps prior to and in prevention of glove events. Systems engineers should be involved in the latent sharps screening of glovebox processes and encouraged to recommend improvements or substitutes to processes, tools, and/or equipment when latent sharps are identified.

Improvements in glove fit will improve dexterity and may make over gloves more feasible while maintaining the needed dexterity. Over gloves are effective at reducing glove events from sharps and latent sharps.

Glove Fit and Selection

The team supports the glovebox glove redesign currently underway with the glovebox ergonomist. The new glove design will improve fit and dexterity and consequently lead to a reduced number of glove events. In addition, the improvements to the glove might provide sufficient dexterity to enable the use of over gloves and further reduce glove events from latent sharps.

Administrative procedure TA55-AP-039, TA55 Glovebox Safety Program – Glovebox Glove Integrity Program, includes guidance for glove selection, inspection intervals, and service life. However, the team recommends a decision tree for glove selection, inspection, and change which should be published and maintained.

The warehouse will be encouraged to maintain an inventory of a variety of gloves with different sizes and materials to better accommodate the different operators and the various processes. In addition, a Lean Six Sigma black belt study will be proposed to improve the glovebox glove forecasts to ensure the availability of needed gloves stocked in the warehouse.

The glovebox ergonomist will visit the rooms within TA-55-PF-4 that are associated with the glove fit and selection glove events to offer specific recommendations. The rooms have been identified.

Engineered controls

The project team strongly recommended that a process be developed to review and approve new items for introduction into gloveboxes. The process is intended to facilitate the implementation of engineered controls. By involving the glovebox systems engineers in glove event investigations the team expects greater identification of corrective actions including ideas for engineered controls. Some of the

engineered controls and new technology should be focused on material transfer and size reduction of equipment.

Glove change

As mentioned above, the team recommends a decision tree for glove selection, inspection, and change which should be published and maintained. Also mentioned above is the recommendation to improve the glove forecasts for the purchase of needed gloves.

CCS-6, Statistical Sciences, is currently conducting an evaluation of glove events and glove changes by room and by glovebox. The study should be allowed to continue to the point of recommending a glove change frequency based on the process specific conditions.

The team recommends that glove installation, inspection, events and changes are tracked in a database. The database will facilitate the recommended change frequency and allow for trending.

Finally, the team recommends that pressure check methods for the glovebox gloves be identified and executed. The pressure checks can identify pinhole leaks before they are visually obvious.

Improve Conclusion

In general, the recommended solutions include the following:

Best practices

- Improve and standardize the investigation process for glove events
- Ensure the implementation of corrective actions from critiques

Latent sharps

- Screen all processes for latent sharps
- Implement the cheesecloth analysis on a regular basis
- Improve the dexterity of gloves to allow for the use of over gloves

Glove fit and selection

- Redesign the glovebox glove
- Establish the variety of gloves to be stocked in the warehouse

Engineered controls

- Develop a process to review and approve new engineered controls for introduction into gloveboxes
- Involve glovebox systems engineers in investigation and corrective actions to inspire new engineered controls
- Implement new technology (material transfer, size reduction)

Glove change

- Create decision tree for glove selection, inspection, and change
- Establish a pressure check method for glovebox gloves to identify breaches before they are visible
- Improve glove forecast
- Complete statistical study of glove events by process

- Improve glove tracking to facilitate a prescribed change schedule

Control

The control phase is the final stage in the black belt process and prescribes the steps for implementing the potential improvements, managing the process after improvement implementation, and validating the improvements against the project goals. The prescribed steps are listed in the implementation plan presented in the appendices.

Implementation Plan

The implementation plan included in the appendices summarizes the actions recommended to be set in motion and people recommended to be engaged to reduce the number of glove breach and failure events. TA-55 management will select from the recommended improvements and assign the appropriate personnel to oversee the implementation through PFITS.

In general, the implementation plan includes actions to inform and engage management and glovebox operators; improve and maintain existing glovebox glove data; record and maintain newly proposed glovebox glove data; improve and standardize the glove event investigations; improve documentation and guidance for glove selection, inspection, and change; improve hazard identification and evaluation process for latent sharps; continue with the glovebox glove redesign; ensure the implementation of recommendations that result from glove event investigations and critiques; develop a process to evaluate and approve new engineered controls for introduction into the gloveboxes; establish a process to pressure check glovebox gloves; and validate the improvements.

Control Plan

The Glovebox Safety Program currently maintains a bar chart with monthly data for the glovebox glove breach status. It is recommended that the current bar chart is replaced with a control chart and is maintained and populated with RPO data for the number of glovebox glove breaches and failures as reported by the Radiation Protection Division. A control chart will be developed and provided to the Glovebox Safety Program to be maintained as a replacement.

Improvement Validation

The implementation plan includes the steps that will be employed to validate the improvements associated with this project. Validation will include an update of the primary and secondary metrics as well as the capability analysis. Validation will also include review of the financial investments to implement the recommendations. Graphical analysis will be used to confirm a difference in the number of RPOs reported before (baseline of 2.7 events per month) and after the implementation of recommendations. Validation will be performed by the black belt.

Validation will be performed in calendar year 2015 to allow for implementation of improvements, the resumption of operations, and sufficient time for routine operations to continue with the reporting and tracking of RPOs.

New Process Capability

The process capability analysis will be updated at the time of validation. The defect analysis described under Measure will be repeated for attribute data associated with the number of glove events to determine the capability of the process after implementation. The binomial spreadsheet will be populated with appropriate number of months and the number of defect months with glove event RPOs above the target of 1 glove event RPO per month.

Cost Analysis

This section summarizes costs for implementation of potential improvements and expected savings.

Recommendation Costs

Most of the improvements recommended in this study endorse ongoing initiatives (ex. glove tracking database, statistical study of glove changes, and the glove redesign), reinforce the need to implement established procedures (corrective actions from glove critiques and glove investigations) or involve current staff who have already been planned and budgeted.

However, a few of the recommendations could potentially involve an investment and/or increased costs. In particular the recommendations include the design and execution of engineered controls and pressure check systems for the gloves. In addition, the team acknowledged that all of the suggestions for additional engineering support might justify the need for a dedicated engineer.

At this time, the recommendations are still in the exploratory phase and therefore the recommendation costs will have to be documented at the time of validation.

Savings & Benefits

Benefits are realized as the number of glove events decline. This study offers suggestions for influencing the factors that contribute to glove events. With each glove event prevented, LANL saves an average of \$23K on the waste disposal and labor associated with the investigation, mitigation, and reporting. Additional savings are expected from the increased productivity of the facility.

Team Listing

The following table includes a list of the project team members and the roles that each member played.

Name	Contribution	Organization
Howard Granzow	Champion	TA55-OPS
Robert Baran	Glovebox Glove Program	TA55-OPS
Vince Garcia	Glovebox Worker	NPI-3

Name	Contribution	Organization
Cindy Lawton	Ergonomics	DSESH-TA55
Kayla Martinez	Data Mining	TA55-DO
Gene Ortega	System Engineering	ES-55
Dennis Padilla	Glovebox First Line Manager	NCO-2
David Wannigman	Rad Protection	DSESH-TA55
Jackie Hurtle	Black Belt	LSS

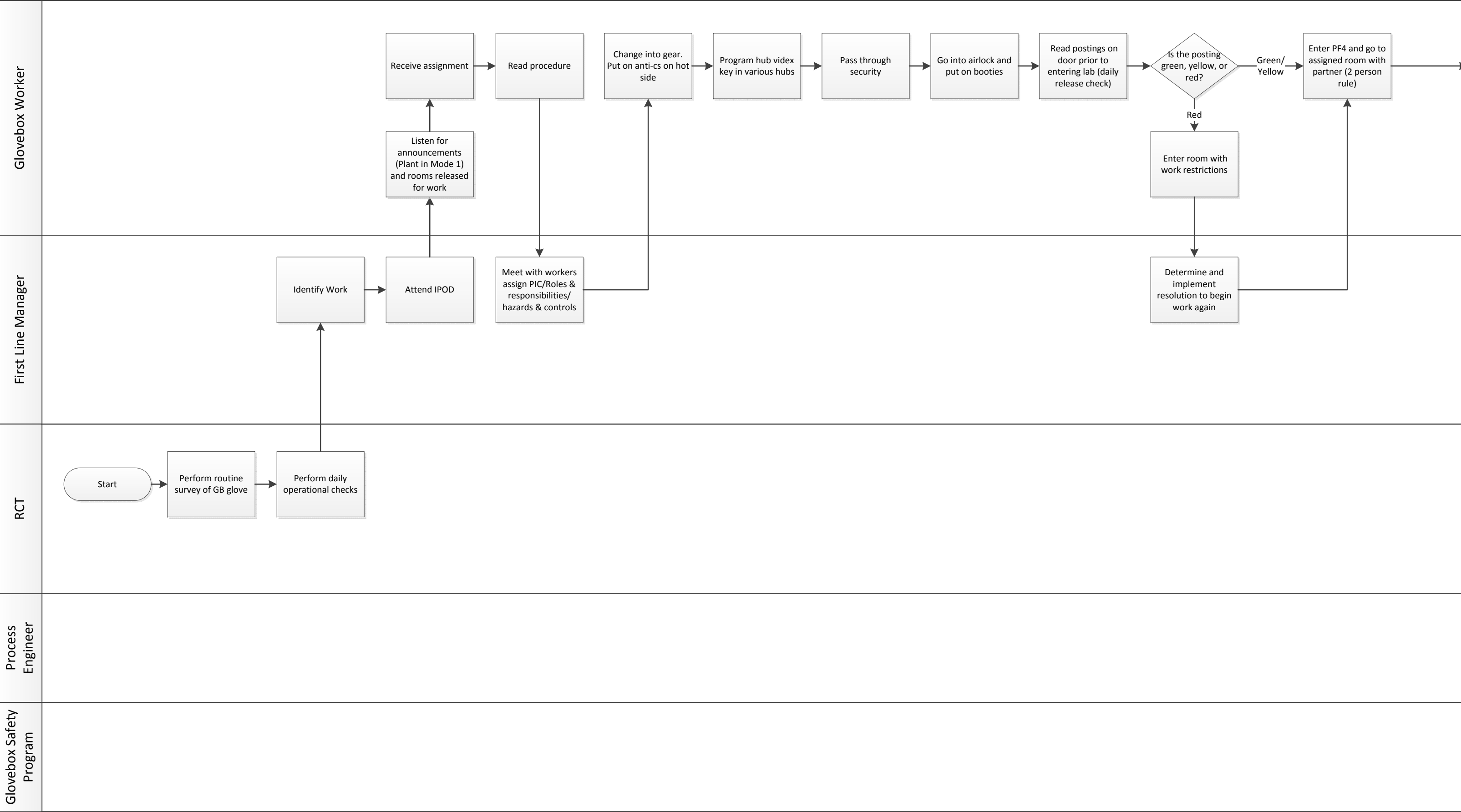
In addition, Danny Borrego, Michael Cournoyer, Regina Fuchs, Chester Smith, Diane Spengler, Stanley Trujillo, and Dianne Wilburn also provided significant contributions to this project.

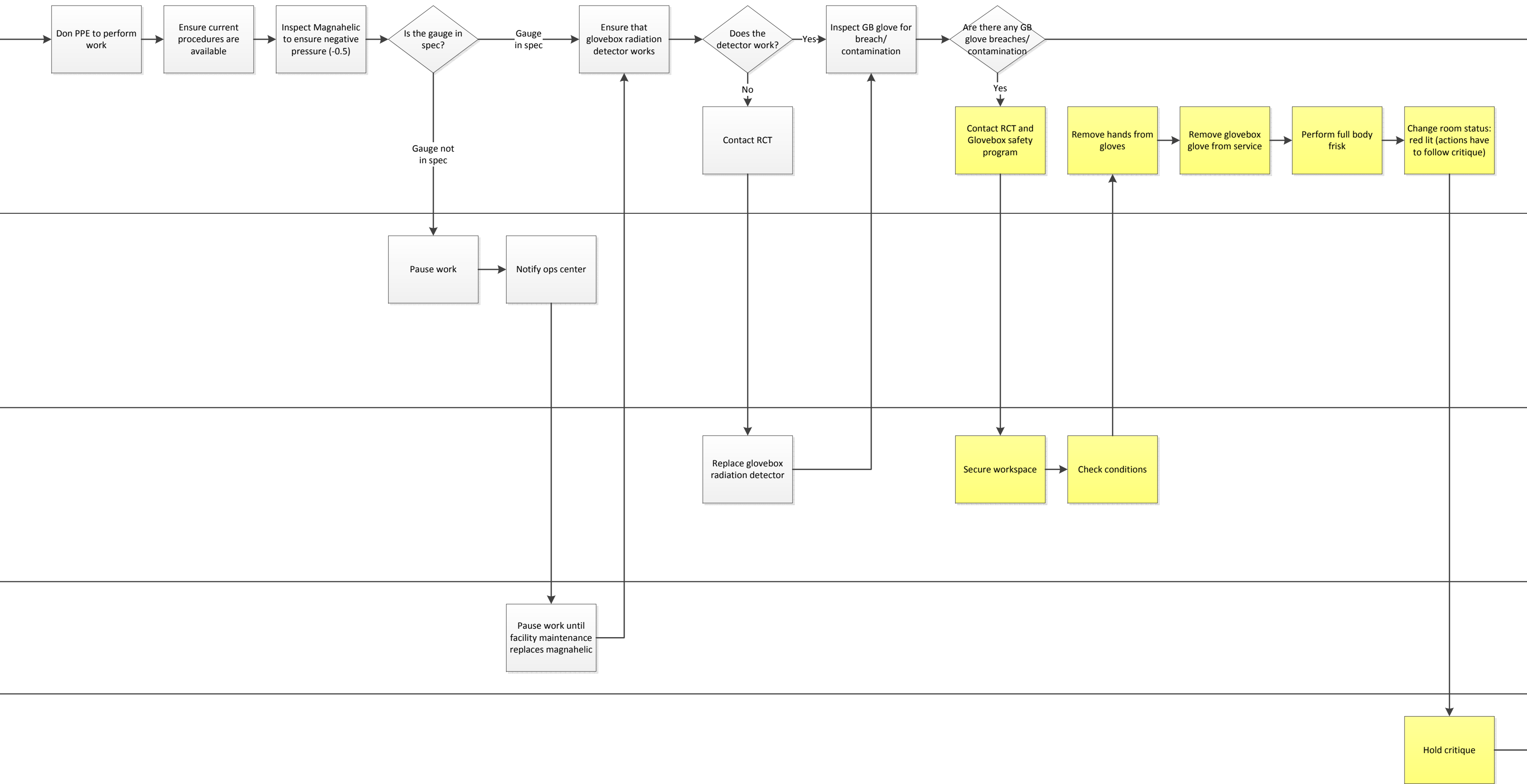
I acknowledge the hard work and contribution of all those involved. Thank you.

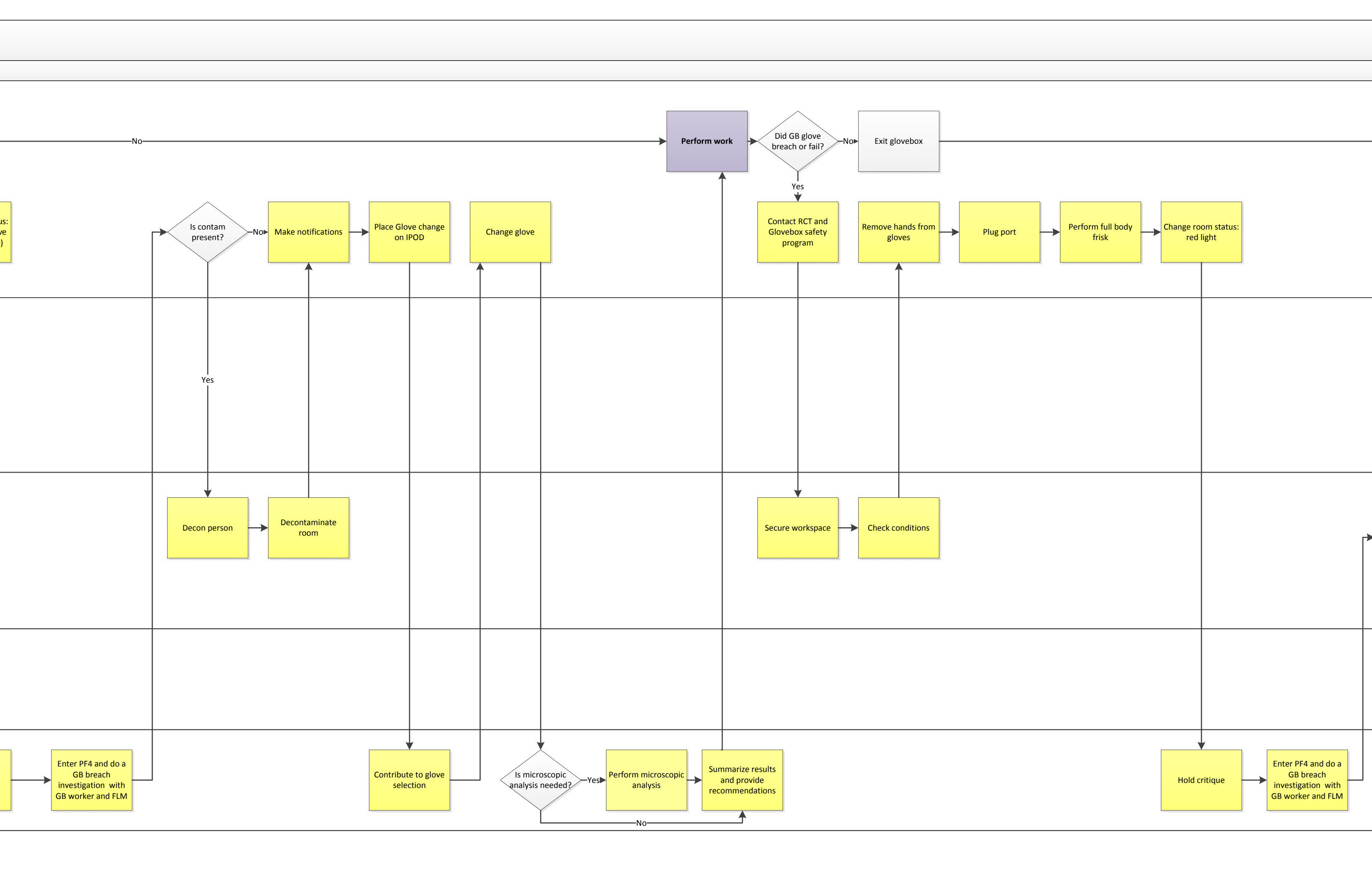
Appendices

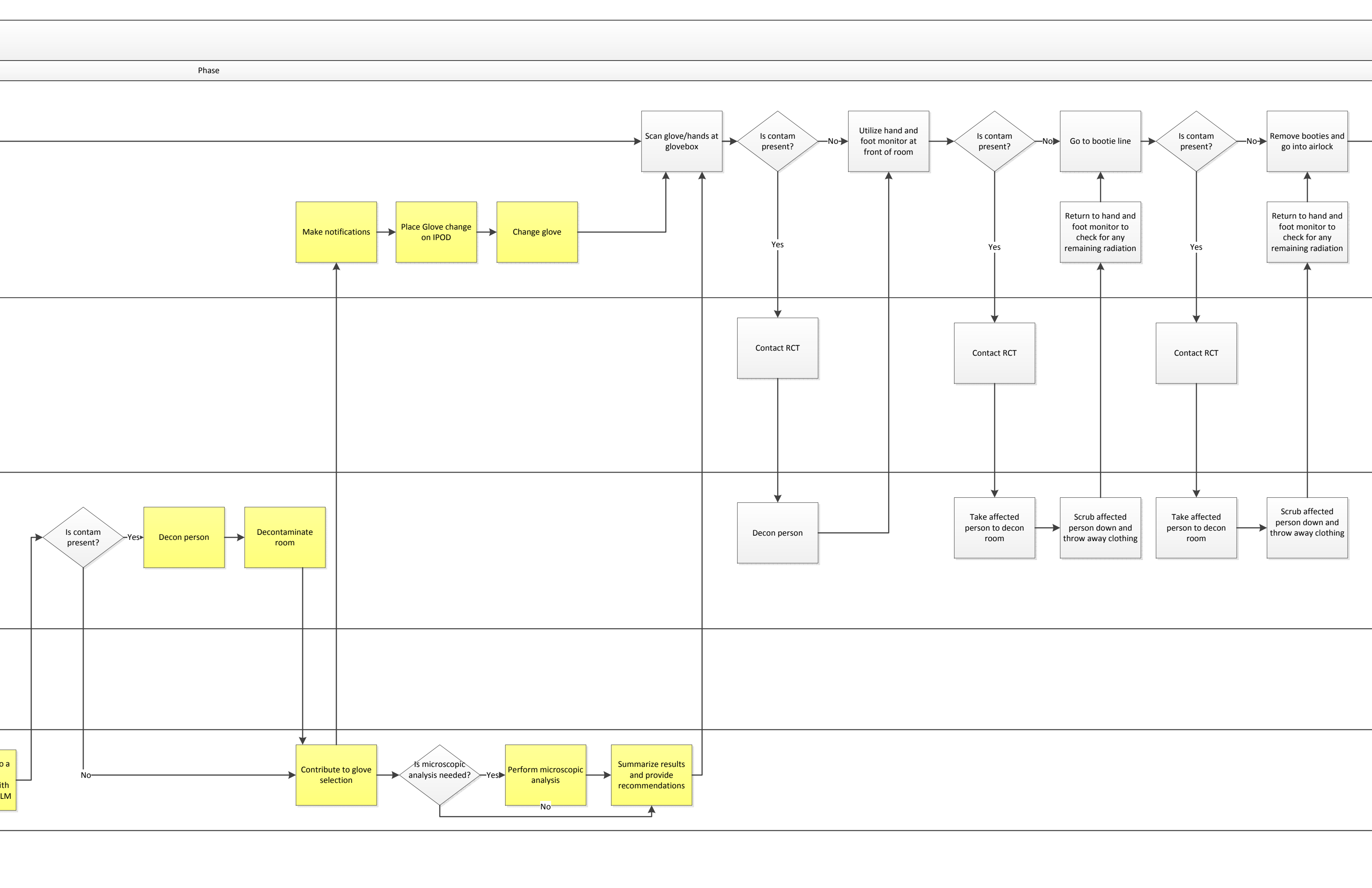
Detailed Process Map

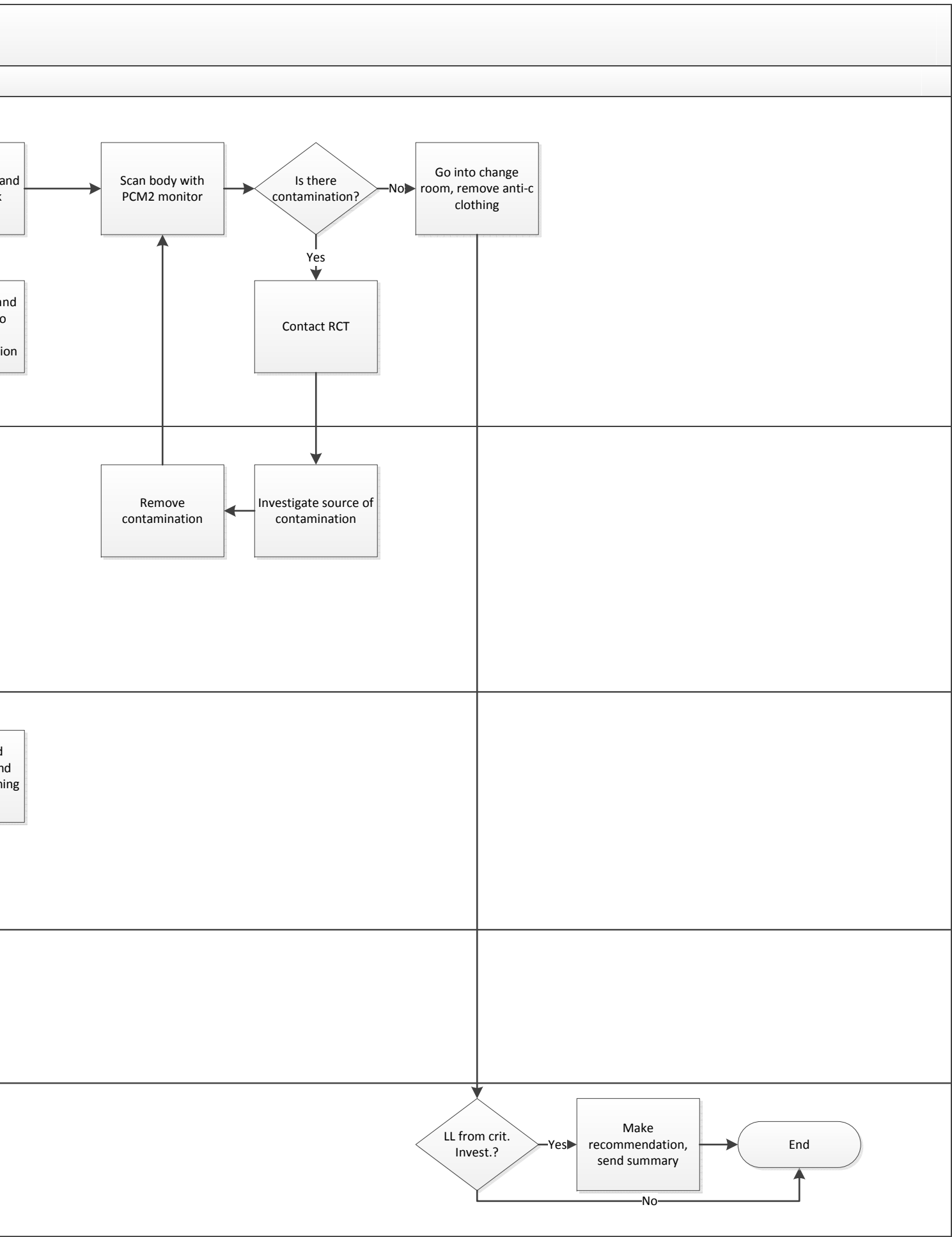
Decrease Glove Breaches and Failures Process Map











Customer Interview Results

VOC: Customer Questionnaire
Process: Glovebox gloves

1. Describe the nature of your rad operations performed in gloveboxes?

The first question was introductory and responses are not captured in this summary.

2. What kind of glovebox problems/concerns do you encounter in the execution of your programmatic work?

Works with Plutonium 238 (Pu-238) aqueous process and chemicals including hydrofluoric acid (HF), concentrated nitric, dry chemicals, sodium hydroxide. These materials damage the gloves.
Containers and tools cause mechanical damage to the gloves
Radiologic damage is a concern (Pu-238 powder damage, damage from head space gas off radioactive materials and chemicals)
The agents that damage the gloves also damage the glovebox gaskets
Ergonomic problems
Risk of glove breach because of metal handling and sharps
The glove is biggest glovebox concern. Gloves are vulnerable because they have to provide dexterity
Lose sleep issue: A glove breach as a result of a puncture is likely to lead to a body burden.
Changing the right gloves at the right frequency
Maintenance of Glovebox performance including ventilation, confinement functionality, facility services
Fix those problems with ventilation, confinement functionality, and facility services of glovebox
Age of glovebox (gaskets)
Adequacy of equipment attached to glovebox such as differential pressure measurements
The hazard classification of the facility makes work difficult (engineering)
The equipment is old and outdated making the work harder on the employees
The gloveboxes are not properly sized for the work being performed
The fire combustible loading restricts changes which would make work easier
Takes a lot of effort and a long time to make changes to the glovebox
Check pressure of box (negative) (were the gloves in or out?)
Inert atmosphere (glovebox readout measured in ppm)
Breach of glove-carefully inspect
Not enough room outside or inside (limited space) of glovebox
Maintenance is difficult because of glove dexterity
Leaded gloves are heavy and hands get tired quickly
Need longer gloves for reach
rejected gloves from quality assessment group
inconsistent procedures for procurement and inspection of gloves
different applications of same type gloves
Make sure good 214 (contamination monitor) is available at the glovebox. They are usually there but not always functioning
Gloves fail

Glove inspections (every 2 years) not completed on time and result in an inspection with respirator on
People not monitoring at glovebox
Ergonomic (physical risk) injury
Contamination of people
Contamination of areas and equipment
Ability to operate
Contamination control is a primary concern for effective radiation protection programs
Glovebox failures are a primary contributor to contamination
No consistency in glove management and they fail sporadically and without warning
Loss of glove integrity (not from work, but failure of glove material such as old age)
Loss of glove integrity (from work ex. heat and sharps)
Improper size of glove (large operator could cause stress)
Resource availability (i.e. RCT, this has been addressed by funding RCT for my programmatic work).
Waste Management Room availability (i.e. competition for use of the room between multiple organizations).
Scheduling of Vault Appointments (i.e. competition from multiple organizations for access).
Loss of rooms to contamination releases.
Gloveboxes and gloves fail contaminating unsuspecting and under protected workers
Similarly, gloveboxes & gloves fail without indications to the worker that might prevent contamination
Glovebox gloves provide less radiological shielding than the glovebox walls, floors and windows
Glovebox consumables (e.g., High-Efficiency Particulate Air (HEPA) filter and gloves) require replacement exposing workers to hazards
Glove breaches (includes breaches and failures)
Glove vendor supply: Timing - can we get gloves when needed
Glove vendor supply: Quality -LANL does not use standard gloves
Have accountable material removed prior to start of new work.
Ergonomic issues: the glovebox is not developed for ease of use.
Lack of properly designed tools for glovebox environment.

3. Is the glovebox functionality or availability a concern in meeting your programmatic work commitments?

Yes, can't make the gloveboxes ergonomically safe because of the old design
Gloveboxes are used for processes that they were not designed for
There is no path for disposal for gloveboxes and therefore they get re-purposed
We design equipment to make the gloveboxes functional
Issues with not enough storage space for nuclear materials at heavy processing times
Numerous times the room is red lit
Impact to the worker
Loss of reputation for the Lab
Office of enforcement and imposed fines
Facility productivity

Design changes for improvements complicate things and involve project management
Needs streamlined engineering and safety basis to make work more efficient
The function is always a problem since most operations which the glovebox was designed for are no longer being performed in that GB.
Availability is not a concern.
Contaminate a room and it is offline for days
No, because there have been no upgrades to the glovebox. Upgrades take time and cause the glovebox to be unavailable.
appears that glove availability is always an issue
functionality of gloves are 50/50 due to "one size fits all" gloves
Have been a concern because the gloveboxes are too old. They were built in 60s and moved to TA-55 from DP road (TA-21 Disposal of Plutonium site)
Gloveboxes need to be replaced
To release a room after a contamination event, it is a big effort
Yes, when glove integrity is lost, work must stop to avoid worker exposure and spread of contamination
Protect the worker to meet programmatic deliverables
Glovebox functionality contributes to glove failure by design (gloves get stressed)
Yes, was a concern (significant breaches impact work and room gets red lit. Room 420 was out of service for 4 months)
Suspect glove can shut down a room
Have to make up lost time up with overtime to meet programmatic deliverables
Availability of waste management room because of multiple organization use (addressed at IPOD/Room Controller).
Availability of Waste organization for Visual Inspections and Evaluations of waste for discard.
Availability of Non-Destructive Assay (NDA) because of multiple organization use (queue for acceptance of materials for NDA.
Availability of Rooms lost to contamination releases.
Releases from glovebox failures suspend programmatic work activities for hours, days, or even weeks
Although rare, personnel with internal dose overexposures can't work in the plant for the rest of the year
Not a problem due to gloves
Availability problematic because of criticality and rad contamination

4. What are the greatest glovebox challenges?

Working through the shielding when doing high dose activities causes ergonomic issues, requires reaching, and poses visibility problems as a result of the thick shielding.
Gloveboxes are old and they leak (through gaskets)
Storage space for nuclear material
Ergo problems. Cindy does good job. She is proactive and follows through
We are not changing the right gloves at the right frequency
Catch the breach or failure immediately
Repair of gaskets. All glovebox work is hot job (windows, panels, etc.)

Design engineering
Setting the glovebox up with workers in a neutral position
Time to make changes
Fire loading restrictions
A criticality board has to approve the introduction of a process or equipment into the glovebox.
Training to perform job in Glovebox
PPE and respirator
Limited space (in/out of the glovebox)
Height of the glovebox requires workers to have stands which tend to get in the way
Maintenance is difficult to perform with gloves when the valves and lines are so small
There are no shelves when working in upper level gloves and no place to put tools
understanding how gloves are breached
knowing when/if a glove should be changed
Windows-clarity (glass fogged and etched)
Gloves only come with one finger size
Proper monitoring of glovebox workers
Glovebox glove inspections
Glovebox inspection: negative pressure, glove dates, swipe, tears
Ergonomics (even glove inspections put strain on hands and back)
Ability to forecast failure: Options -replace all gloves on periodic basis to prevent failure or breach or -forecast needed change before glove fails or breaches
Finding pliable yet puncture proof or resistant glove material
Finding mechanical aids to do work (instead of sharps). Creative ways to perform work
Incidental sharps
Undetected failure that leads to spread of contamination (contamination gets out the door)
Diversion of resources
Concerned about RP staying connected to work because of deployment (ADESH transformation)
Gloves are weakest point in the glovebox and an operator will be in and out approximately 20 times in a morning
Ergonomics-height, work, weight, repetitive motion
Some equipment is old and came from DP site. Some gloveboxes were moved from DP road to TA-55
TA-55-PF-4 built in 70s
It takes 5-8 years to remove old equipment and install new. Heavy equipment, sharps, and old equipment are higher risk
Availability of waste management room because of multiple organization use (addressed at IPOD/Room Controller).
Availability of Waste organization for Visual Inspections and Evaluations of waste for discard.
Availability of NDA because of multiple organization use (queue for acceptance of materials for NDA.
Availability of Rooms lost to contamination releases.
Failures resulting in airborne contamination to unprotected workers
Ergonomic issues resulting in worker injuries
Difficult (impossible?) to modify the configuration of a glovebox to meet changing programmatic

needs
Seismic support to upgrade boxes (new seismic standards which evolve conservatively)
Fire codes (interpretation of code-install sprinkler in GB, this is not practical)
Opinionated requirements need to be balanced with functionality
Ergonomics
The preventative maintenance program has just been in place for about 3 yrs. Before that, process maintenance was done by process technician and engineer
MET owns process equipment: can also have NCO or NPI doing maintenance

5. Do your glovebox gloves work for you?

Yes and the worker has tried a variety of gloves. Default to North/Honeywell, 30 mil leaded. For smaller builds is it important to stock 30 inch length gloves
Blue gloves delaminate in 2 weeks in actinide processing
The worker is satisfied with the dose protection
Ergo issues. Cindy is offering gloves with rad protection but greater dexterity
Confident in glovebox dose protection
No problem from maintenance issues on gloves
The fit of the glovebox glove is not appropriate and provides more wear and tear and is hard to get anything done wearing the gloves
Inner gloves and over gloves make work very difficult
Provides input to the glove choice (try them on)
Factory expiration date
Require inspection
Clean the glove to prolong the use
Gloves are heavy and too short
Gloves are sufficiently durable
Gloves adequately protect from radiation
It is a good practice to adjust the glove for the activity (do not needed leaded gloves in the drop box)
yes, gloves used in facility appear to be appropriate for jobs
no, difficult for some workers to effectively do job, due to "one size fits all" gloves
Size problem
Function okay
Workers could do a better job inspecting and changing gloves
Replace gloves within 10 yrs of glove date
Replace gloves more frequently after high use or high hazard
Machining gloves should be changed annually
No, because we have failures and breaches leading to contamination
Glovebox gloves need to be improved because they fail and create contamination problems and lead to uptakes
Yes, without gloveboxes and their equipment and facility support infrastructure, operating groups would not be able to provided programmatic deliverables
Yes (i.e. 30mil North/Honeywell gloves).
Yes (i.e. R&D work 20mil gloves).

Moderately successful (B+) in benign work environments (no sharps, furnaces or harsh chemicals)
Barely adequate (C-) in harsh work environments
Balance-ergo, dose, dexterity
New technology hard to justify with installation constraints (long term need for the equipment and functionality)
Strong justification required to put new technology in GB
\$200,000 for GB, and Chemistry and Metallurgy Research Replacement facility (CMRR) was planned for 400. Total cost was estimated at \$80 million
How do we pilot new technology?
As best as they can
Limitation with dexterity (detailed work difficult)
Need to avoid sharps
Benign things can be problematic in the glovebox environment

6. What causes glovebox glove breaches and failures?

Rad damage to the glove
Chemical damage
Wear
Accidental mechanical damage
Workers become complacent. They don't consider hazards during times of high productivity
Sharps
Pinch points (trolley buckets)
Sharps and shards
Failure to identify suspect glove and make the extra effort to change the glove
Glove selection and change out due to the frequency of use and the diversity of activities
Diversity of operations (maintenance, machining)
Frequency of usage
Puncture, tears
Housekeeping issues, improper tools, improper fit of glove causing wear and strain issues
Outdated equipment, rushing to get work done, worker fatigue, poor grip on tools
Poor design or wrong design of GB for process
Carelessness of sharps (wear extra gloves-over gloves)
Burns from furnace
Wear out
Aqueous nitrate solutions cause blistering of the gloves (change glove when blistered)
Sharps
Unsuspecting sharps
High use requires more frequent change out
human performance
inadequate tools
glovebox housekeeping
Performing the work

Protective measures make work much more difficult
Mechanics of work-sharps, machining, wrenches, wires
Aqueous process chemicals-acids and bases
Maintenance (especially trolleys)
(Multiple users) lack of ownership
Failure of the glove with wear and tear over time, material vulnerabilities, routine contact with materials that lead to failure, handling sharps that lead to breach
Materials, tools, equipment
Worker understanding to exercise care to avoid glove breaches and failures
Sharps
Heat source degradation
Chemical degradation
Quality
Gloves are not changed out at a predictable frequency
Use leads to failure that isn't understood (pokes, abrasives, wear and tear, environmental issues)
Is design of glove up to date? Should we make a better glove?
Sharps
Loss of integrity of glove-chemical, heat, poor installation, old age
Wrong size, lead lined glove comes small or large
Inventory control is problematic but work continues with what you have
Predominately 2 types of gloves being used
Wear on gloves from repeated operational use.
Extension of gloves instead of changing gloves when expiration date (e.g. < 2years).
Age of glove on glove boxes.
Unexpected sharps and hazards encountered (e.g. metal sliver in oxide materials).
Antiquated work practices involving manual labor (e.g., crucible breakout) where tooling could be used
Worker inattention to detail and/or violation of established safe work practices (e.g., using the wrong tool)
Sharps-we need to use these tools
Defects from vendor
Trolley-gloves, ownership issue, keeping them maintained, gloves degrade over time
Wear and tear, especially in an acidic environment, operation specific, how much work is done (how do we normalize for usage)
Physical size of GB workers, 6ft-6in 350 lb operator has unique challenges
Depends on the area-chemical degradation, mechanical failure, radiation, people treat them as work gloves and they are not as durable, stretch could lead to breach

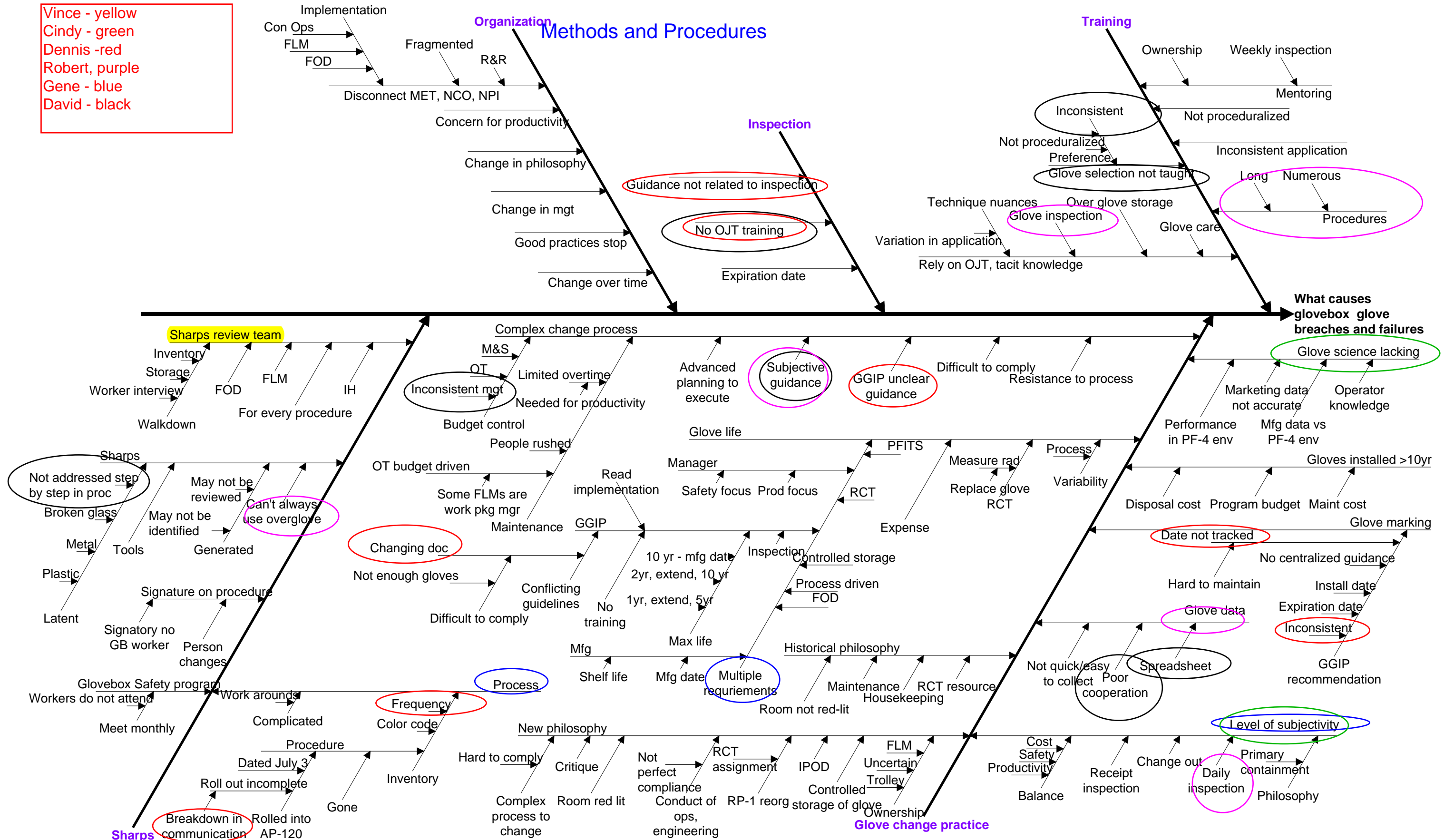
7. Is there anything else I should know?

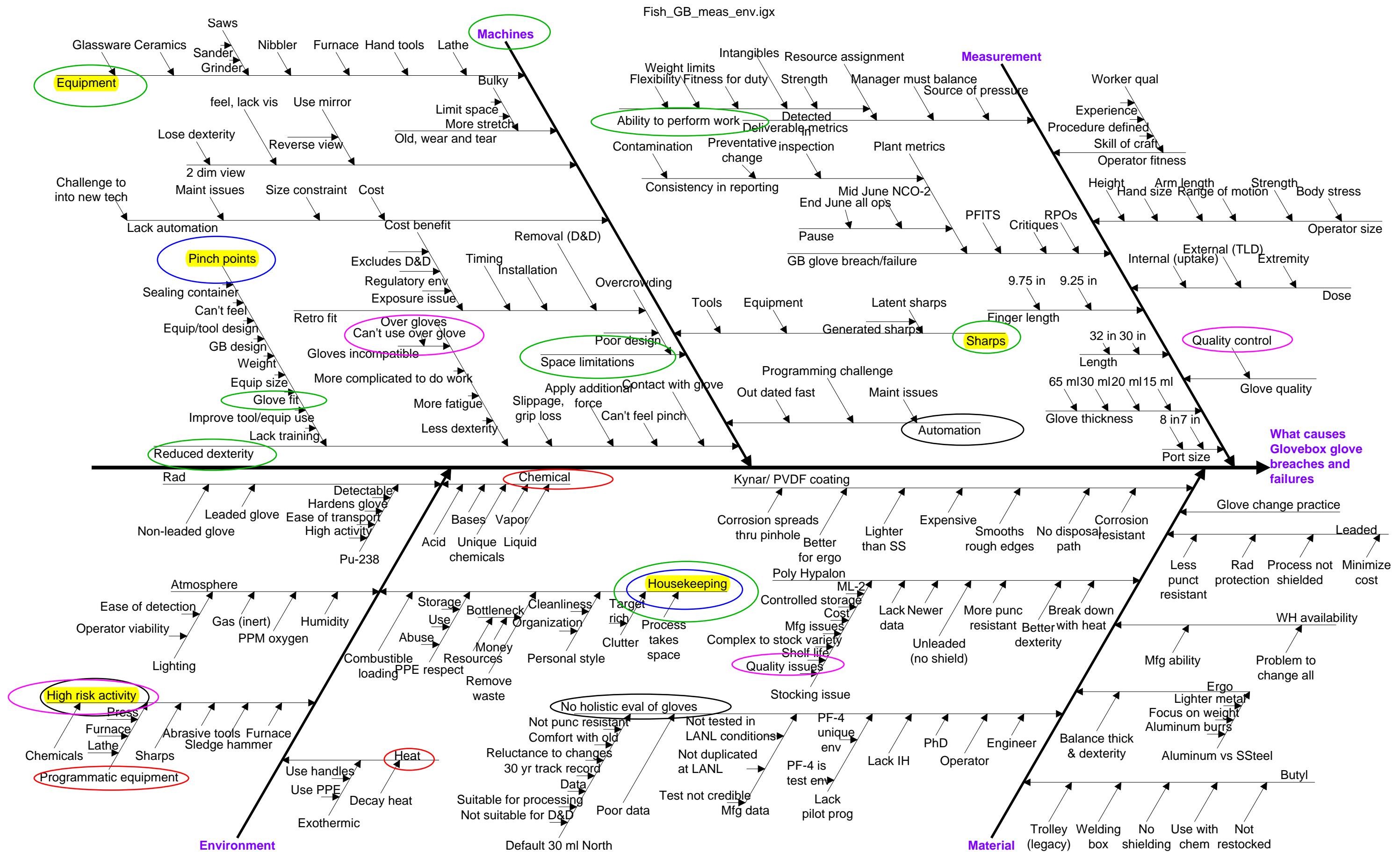
Recommend: LA-13918-MS Glovebox glove failure analysis
Actinide processing has switched to star shaped knobs to protect the gloves and operate the knob
The color red does not last in box
Glove change frequency is at the discretion of the operator

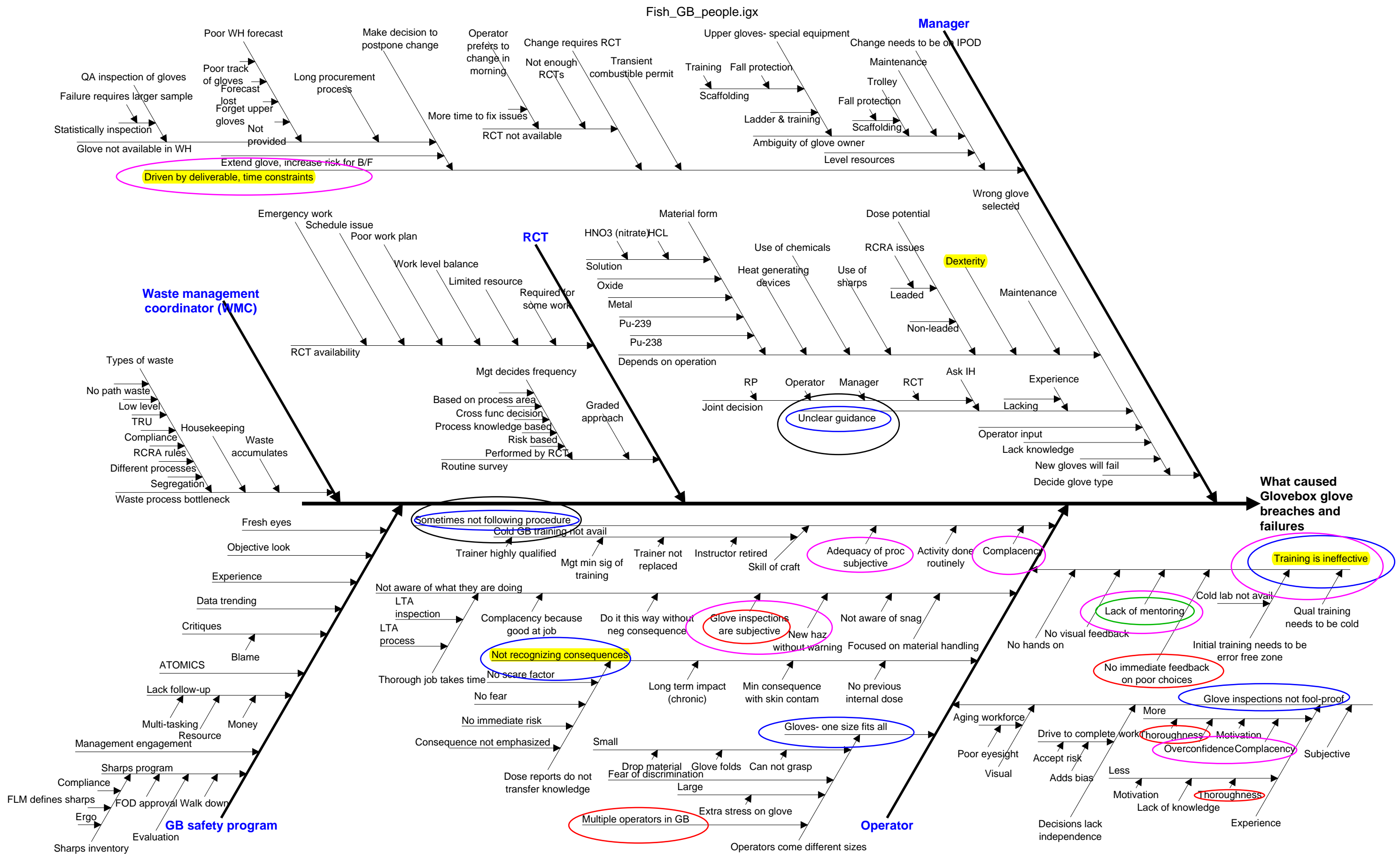
The actinide processing gloveboxes are thermally hot environments and therefore the gloves need to be kept outside the gloveboxes
Thorough inspection of the gloves involves cheese cloth swipe with rad monitoring and visual exams
Lead is not good shielding for Pu-238
Orange on the gloves is the indicator for wear
Rigorous housekeeping and maintenance is necessary
Workers never put programmatic needs before glove changes
Workers handle materials with extension tools to maintain distance between the worker and the rad material.
Email Cindy regarding the need for 30 in. length gloves
North/Honeywell gloves are handmade with a dipping process. As a result, the gloves are not uniform.
The gloves are subject to rigorous quality assurance checks.
The worker has to balance how long to do the job and the protective measures to ensure a safe job. Protective measures usually require more time to complete the job.
The removal of one hazard typically causes another.
Jackie Seay (former glovebox worker) is aware of who maintained glovebox change data
Glove change data does not belong on the Master Equipment List. Gloves are consumables.
Diane will send glove change data that she maintained for 4-5 years. She is confident that the data is complete for the period of time that she was collecting it.
Pu-238 – Glove change data was recorded by Diane
Pu-239 – Glove change data was collected– ask Jackie Seay who kept this data
LTI are poor gloves for actinide processing. The gloves delaminate.
Ozone is suspected to attack gloves. When the spool door is closed, ozone builds up in the glovebox.
Need to look in glovebox before put hands in
Glove inspections are not being performed. But this has gotten better
Tendency to go in and out of gloves repeatedly and it is impractical to inspect each time.
People take short cuts when productivity is high
Glove inspections needed before the job-but twice a day is sufficient
Leak detected plugs that tell you if you have a leak
Plug ports when glove is not used for a period of time
If the glove change were easier (not cheaper) would the operators change them more often
Change the financial model so that the decision to change the glove is not a financial decision.
Breach is not really a big issue (someone considers it loss of contamination control)
Get people to care about work and follow procedures
Need to check hands immediately every time-catch contamination at the source
Strong peer review, buddy system
37 years at PF-4, honor to work for LANL
Given guidance to cut down on glove replacement because of cost
Most work done in one glovebox
TA-55 has gotten better on On-the-Job Training of glove changes
TA-55 is better at awareness of work and the hazards

TA-55 is better at inspecting gloves
TA-55 has better awareness that increased use will result in more frequent glove change
1st principle for those who use tools - are they trained? Do they receive mentoring, coaching?
Radiation is one piece but don't underestimate ergonomic issue
Radiation protection and ergonomic issues need to work hand and glove
Secondary metrics-good: number of gloves(represent waste stream), ergonomic injuries, dose, and facility availability
Can we reduce the hands on/in box?
Reduce the exposure
Room 429 has had a number of breaches
With 10 breaches, 7-8 are good catches
Glove is weakest point in the overall glovebox containment system
Gloves are consumable and inexpensive compared to overall budget
1000 people employed at TA-55
Crap up (rad contamination) room and it will be off-line for a long time. Then there is a big effort to clean and get it back on-line
ATOMICS to change behavior-get people to recognize what they are doing
What is the glove shelf life, how is it determined?
Barcode reader has been approved for security area (ask Brad), can we use the technology to help with glove tracking?
Needs balance: dexterity for work and protection of glove (with over glove)
Customer has had 4 breaches, 3 subtle, one gross
Equipment installed without consideration for removal
Develop methods to make job safer: wizard bag to break glass

Fishbone Diagram







FMEA Spreadsheet

Potential Failure Modes (process defects)	Potential Failure Effects (Ys)	SEV	Potential Causes of Failure (Xs)	OCC	Current Process Controls	DET	RPN
Poor glove selection	Glove breach and degradation	10	GB process	9	None	10	900
Lack scheduled glove change	Glove degradation	10	Arduous process to plan glove change	9	None	10	900
Lack of appropriate gloves in the warehouse	Glove breach	10	Difficult to predict glove demand	9	None	10	900
Long reach within the GB	Glove tear	10	Cross functional changes are difficult	9	None	10	900
Lack of funding (owned by FOD and not program)	Glove breach	10	Machines are not replaced	9	None	10	900
Lack of funding (owned by FOD and not program)	Glove breach	10	Cost estimates are not realistic	9	None	10	900
Poor GB design	Glove breach	10	Lack of communication between design team and GB user	9	None	10	900
Poor glove fit	Glove breach	10	Limited glove size available from manufacturer	9	None	10	900
Poor glove fit	Glove breach	10	No ability to switch glove for operator	9	None	10	900
Poor glove selection	Glove breach and degradation	10	Limited glove size available from manufacturer	9	None	10	900
Poor glove selection	Glove breach and degradation	10	No ability to switch glove for operator	9	None	10	900
Lack of appropriate gloves in the warehouse	Glove breach	10	Extension of glove use	9	None	10	900
Poor hand tools	Glove breach	10	Cross functional changes are difficult	9	None	10	900
Lack of appropriate gloves in the warehouse	Glove breach	10	Difficult to predict glove demand	9	Current development of database	9	810
Crowded glovebox	Glove breach	10	Poor engineering of equipment in GB	9	Change control board	9	810
Crowded glovebox	Glove breach	10	Poor engineering of equipment in GB	9	Program management working board	9	810
Crowded glovebox	Glove breach	10	Reuse system (repurpose GB)	9	Change control board	9	810
Crowded glovebox	Glove breach	10	Reuse system (repurpose GB)	9	Program management working board	9	810
Inattention	Glove breach	10	Line of fire (contact with glove, ex. is cart)	9	IPOD	9	810
Inattention	Glove breach	10	Line of fire (contact with glove, ex. is cart)	9	Communication	9	810
Machining equipment	Glove breach	10	Unaware of sharps	9	Pre-job brief	9	810
Poor hand tools	Glove breach	10	Limited supply of tools	6	None	10	600
Lack scheduled glove change	Glove degradation	10	Variety of processes	6	None	10	600

Potential Failure Modes (process defects)	Potential Failure Effects (Ys)	SEV	Potential Causes of Failure (Xs)	OCC	Current Process Controls	DET	RPN
Lack scheduled glove change	Glove degradation	10	No tracking of glove use	6	None	10	600
Long reach within the GB	Glove tear	10	Poor glovebox design	6	None	10	600
Using corrosive chemicals	Glove degradation	10	No engineering data to support new gloves	6	None	10	600
Lack of funding (owned by FOD and not program)	Glove breach	10	Poor glovebox design	6	None	10	600
Lack of funding (owned by FOD and not program)	Glove breach	10	Tools are not properly designed	6	None	10	600
Lack of funding (owned by FOD and not program)	Glove breach	10	Replacement takes too long	6	None	10	600
Lack glove tracking database	Glove breach and degradation	10	No predictive maintenance	6	None	10	600
Inattention	Glove breach	10	Aging work force	6	None	10	600
Improper glove inspection	Missed glove breach	10	Complacency	6	Stay operational	9	540
Improper glove inspection	Missed glove breach	10	Gloves dirty	9	Wipe down gloves	6	540
Crowded glovebox	Glove breach	10	Multifunctional GB	6	IPOD	9	540
Inattention	Glove breach	10	Unaware of consequence to glove	6	Communication	9	540
Inattention	Glove breach	10	Unaware of consequence to glove	6	Pre-job and post job brief	9	540
Poor glove fit	Glove breach	10	Lack of dexterity	9	Thinner gloves	6	540
Heat sources	Glove breach	10	Pu-238	9	Over glove	6	540
Heat sources	Glove breach	10	Pu-238	9	Packaging	6	540
Heat sources	Glove breach	10	Pu-238	9	Tongs	6	540
Poor hand tools	Glove breach	10	Decreased dexterity	9	Ergonomist	6	540
Poor hand tools	Glove breach	10	Decreased dexterity	9	Getting and using proper tools	6	540
Poor hand tools	Glove breach	10	Corrosion and wear of tools	9	Replace tools	6	540
Poor hand tools	Glove breach	10	Difficult to replace tools	9	Supervision	6	540
Lack of appropriate gloves in the warehouse	Glove breach	10	Delay of glove changes	9	Extension of glove use	6	540
Lack scheduled glove change	Glove degradation	10	Funding (lack to pay for glove change)	6	Sponsor for space	9	540
Heat sources	Glove degradation	10	Pu-238	9	Over glove	6	540
Heat sources	Glove degradation	10	Pu-238	9	Packaging	6	540
Heat sources	Glove degradation	10	Pu-238	9	Tongs	6	540
Lack of appropriate gloves in the warehouse	Glove breach	10	No longer changing glove on regular schedule	6	Current development of database	9	540
Long reach within the GB	Glove tear	10	Lack of sharing between organization and wings	9	Glovebox safety team	6	540
Poor GB design	Glove breach	10	Lack experience to design box for PF-4	9	Recent newly designed GB	6	540

Potential Failure Modes (process defects)	Potential Failure Effects (Ys)	SEV	Potential Causes of Failure (Xs)	OCC	Current Process Controls	DET	RPN
Improper glove inspection	Missed glove breach	10	Accepted risk- take chance	9	Supervision	6	540
Crowded glovebox	Glove breach	10	Poor housekeeping	9	Legacy equipment removal FSR	6	540
Crowded glovebox	Glove breach	10	Poor engineering of equipment in GB	9	Redesign	6	540
Crowded glovebox	Glove breach	10	Poor engineering of equipment in GB	9	ESR	6	540
Crowded glovebox	Glove breach	10	Poor engineering of equipment in GB	9	Equipment life cycle guide	6	540
Crowded glovebox	Glove breach	10	Poor engineering of equipment in GB	9	Engineering specs	6	540
Crowded glovebox	Glove breach	10	Poor engineering of equipment in GB	9	Individual worker initiative for change	6	540
Crowded glovebox	Glove breach	10	Reuse system (repurpose GB)	9	GB redesign	6	540
Crowded glovebox	Glove breach	10	Reuse system (repurpose GB)	9	ESR	6	540
Crowded glovebox	Glove breach	10	Reuse system (repurpose GB)	9	Equipment life cycle guide	6	540
Crowded glovebox	Glove breach	10	Reuse system (repurpose GB)	9	Engineering specs	6	540
Crowded glovebox	Glove breach	10	Reuse system (repurpose GB)	9	Individual worker initiative for change	6	540
Inattention	Glove breach	10	Line of fire (contact with glove, ex. is cart)	9	Over glove	6	540
Inattention	Glove breach	10	Line of fire (contact with glove, ex. is cart)	9	Familiarity with operations	6	540
Inattention	Glove breach	10	Line of fire (contact with glove, ex. is cart)	9	Supervision	6	540
Inattention	Glove breach	10	Line of fire (contact with glove, ex. is cart)	9	Design of GB	6	540
Poor glove fit	Glove breach	10	No ability to switch glove for operator	9	Quick glove change ports and ability to get the correct glove for the operator	6	540
Crowded glovebox	Glove breach	10	Poor housekeeping	9	Supervision	6	540
Poor hand tools	Glove breach	10	Lack of sharing between organization and wings	9	Glovebox safety team	6	540
Lack of appropriate gloves in the warehouse	Glove breach	10	Extension of glove use	9	Cooperation with manufacturer for special delivery	6	540
Lack of appropriate gloves in the warehouse	Glove breach	10	Manufacturer availability	6	Forecast glove demand	9	540
Improper glove inspection	Missed glove breach	10	Accepted risk- take chance	9	Peer pressure	6	540
Poor hand tools	Glove breach	10	Excessive force	9	Over glove	6	540
Poor hand tools	Glove breach	10	Excessive force	9	Better ergo tools	6	540
Poor hand tools	Glove breach	10	Excessive force	9	Use securing device	6	540
Poor hand tools	Glove breach	10	Excessive force	9	Proper tool use	6	540

Potential Failure Modes (process defects)	Potential Failure Effects (Ys)	SEV	Potential Causes of Failure (Xs)	OCC	Current Process Controls	DET	RPN
Lack of appropriate gloves in the warehouse	Glove breach	10	Groups are inconsistent in providing glove forecasts	6	Multiple request for forecasts	9	540
Crowded glovebox	Glove breach	10	Poor housekeeping	9	MOV	6	540
Machining equipment	Glove breach	10	Latent sharps	9	Over glove	6	540
Machining equipment	Glove breach	10	Unaware of sharps	9	Acknowledge of hazards	6	540
Improper glove inspection	Missed glove breach	10	Complacency	6	Fear of uptake	6	360
Improper glove inspection	Missed glove breach	10	Rush inspection to get to work	6	Supervision	6	360
Improper glove inspection	Missed glove breach	10	Bad lighting	6	Flashlights	6	360
Improper glove inspection	Missed glove breach	10	Bad lighting	6	Magnifying glasses	6	360
Crowded glovebox	Glove breach	10	Maintenance	6	Size reduction	6	360
Crowded glovebox	Glove breach	10	Maintenance	6	FSR	6	360
Crowded glovebox	Glove breach	10	Maintenance	6	ESR	6	360
Crowded glovebox	Glove breach	10	Maintenance	6	Criticality safety	6	360
Crowded glovebox	Glove breach	10	Large equipment	6	Better GB	6	360
Crowded glovebox	Glove breach	10	Operator tolerance for work in crowded GB	6	Supervision	6	360
Crowded glovebox	Glove breach	10	Operator tolerance for work in crowded GB	6	Peer pressure	6	360
Crowded glovebox	Glove breach	10	Operator tolerance for work in crowded GB	6	MOV	6	360
Crowded glovebox	Glove breach	10	Multifunctional GB	6	Ownership	6	360
Crowded glovebox	Glove breach	10	Multifunctional GB	6	Criticality safety	6	360
Inattention	Glove breach	10	Fatigue	6	Scheduling	6	360
Inattention	Glove breach	10	Unaware of consequence to glove	6	Supervision	6	360
Inattention	Glove breach	10	Unaware of consequence to glove	6	Hazard Identification	6	360
Poor hand tools	Glove breach	10	Complacency with available tools	6	Supervision	6	360
Poor hand tools	Glove breach	10	Complacency with available tools	6	Ergonomist	6	360
Over aggressive use of glove	Glove tear	10	Inattention	6	Supervision	6	360
Defective or improper handling of expanders and gloves	Glove failure	10	Damage to glove during installation	6	Inspection	6	360
Using corrosive chemicals	Glove degradation	10	Process requirement	6	Store gloves outside after wipe down	6	360
Lack scheduled glove change	Glove degradation	10	Variety of hazards	6	Hazard Identification	6	360
Long reach within the GB	Glove tear	10	Lack of extension tools	6	Ergonomist	6	360
Lack of appropriate gloves in the warehouse	Glove breach	10	No longer changing glove on regular schedule	6	Owner of GB decides schedule of glove change	6	360

Potential Failure Modes (process defects)	Potential Failure Effects (Ys)	SEV	Potential Causes of Failure (Xs)	OCC	Current Process Controls	DET	RPN
Lack of funding (owned by FOD and not program)	Glove breach	10	Lack of mission for the GB	6	Preventative maintenance	6	360
Lack glove tracking database	Glove breach and degradation	10	Improper glove change	6	Owner of GB decides schedule of glove change	6	360
Lack glove tracking database	Glove breach and degradation	10	Glove supply is not adequate	6	Cooperation with manufacturer for special delivery	6	360
Lack glove tracking database	Glove breach and degradation	10	Glove supply is not adequate	6	Flexibility in glove substitution	6	360
Using corrosive chemicals	Glove degradation	10	Process requirement	6	Wipe down gloves	6	360
Lack of appropriate gloves in the warehouse	Glove breach	10	Manufacturer availability	6	Predictive glove change schedule	6	360
Inattention	Glove breach	10	Fatigue	6	Design of GB	6	360
Machining equipment	Glove breach	10	Inadequate maintenance	6	Maintenance schedule	6	360
Machining equipment	Glove breach	10	Inadequate maintenance	6	Request for corrective maintenance	6	360
Long reach within the GB	Glove tear	10	Lack of extension tools	6	Engineering support	6	360
Lack of appropriate gloves in the warehouse	Glove breach	10	Manufacturer availability	6	Controlled storage for gloves	6	360
Lack of appropriate gloves in the warehouse	Glove breach	10	All gloves for LANL go thru TA-55 warehouse	3	None	10	300
Poor glove fit	Glove breach	10	Variety of hand sizes	3	None	10	300
Poor glove selection	Glove breach and degradation	10	Variety of hand sizes	3	None	10	300
Poor hand tools	Glove breach	10	Lack engineering support	3	None	10	300
Defective or improper handling of expanders and gloves	Glove failure	10	PF-4 requires the removal of outer packaging	3	None	10	300
Defective or improper handling of expanders and gloves	Glove failure	10	Schedule changes cause improper storage of gloves	3	None	10	300
Using corrosive chemicals	Glove degradation	10	Slow process to substitute chemicals	3	None	10	300
Long reach within the GB	Glove tear	10	Worker has short arms	3	None	10	300
Using corrosive chemicals	Glove degradation	10	Resistance to change to a new type of glove	3	None	10	300
Poor GB design	Glove breach	10	Resistance to change	3	None	10	300
Poor glove fit	Glove breach	10	Pinch glove	3	None	10	300
Poor hand tools	Glove breach	10	Operator creates own tools	3	None	10	300
Long reach within the GB	Glove tear	10	Operator creates own tools	3	None	10	300
Improper glove inspection	Missed glove breach	10	Operator assumes that RCT inspected glove	3	None	10	300
Poor glove fit	Glove breach	10	Snags glove	3	None	10	300

Potential Failure Modes (process defects)	Potential Failure Effects (Ys)	SEV	Potential Causes of Failure (Xs)	OCC	Current Process Controls	DET	RPN
Improper use of trolley	Glove breach and degradation	10	Poor design of bucket	3	None	10	300
Improper use of trolley	Glove breach and degradation	10	Procedure requires bucket 6 inches from floor	3	None	10	300
Improper use of trolley	Glove breach and degradation	10	Not implementing new design	3	None	10	300
Improper use of trolley	Glove breach and degradation	10	Weight of the bucket-300 lb	3	None	10	300
Lack of appropriate gloves in the warehouse	Glove breach	10	Warehouse space limited	3	None	10	300
Improper glove inspection	Missed glove breach	10	Lack understanding of inspection criteria (assumptions about previous person in box)	3	Communication	9	270
Improper glove inspection	Missed glove breach	10	Gloves dirty	9	Change the glove	3	270
Heat sources	Glove breach	10	Pu-238	9	Training	3	270
Heat sources	Glove breach	10	Pu-238	9	Frequent glove change	3	270
Poor hand tools	Glove breach	10	Corrosion and wear of tools	9	Procedure	3	270
Poor hand tools	Glove breach	10	Difficult to replace tools	9	Procedure	3	270
Over aggressive use of glove	Glove tear	10	Pressure to do work	3	IPOD	9	270
Heat sources	Glove degradation	10	Pu-238	9	Frequent glove change	3	270
Heat sources	Glove degradation	10	Pu-238	9	Training	3	270
Lack of appropriate gloves in the warehouse	Glove breach	10	Delay of glove changes	9	Have money to buy	3	270
Improper glove inspection	Missed glove breach	10	Accepted risk- take chance	9	Procedure	3	270
Crowded glovebox	Glove breach	10	Poor housekeeping	9	Procedure	3	270
Inattention	Glove breach	10	Line of fire (contact with glove, ex. is cart)	9	Procedure	3	270
Inattention	Glove breach	10	Line of fire (contact with glove, ex. is cart)	9	OJT	3	270
Inattention	Glove breach	10	Line of fire (contact with glove, ex. is cart)	9	Time to do work	3	270
Crowded glovebox	Glove breach	10	Poor housekeeping	9	Worker preference (individual cleanliness)	3	270
Machining equipment	Glove breach	10	Latent sharps	9	Procedure	3	270
Inattention	Glove breach	10	Stress and work priority	3	IPOD	9	270
Improper glove inspection	Missed glove breach	10	Accepted risk- take chance	9	Training	3	270
Crowded glovebox	Glove breach	10	Poor housekeeping	9	Combustible limits	3	270
Machining equipment	Glove breach	10	Latent sharps	9	Worker experience	3	270
Machining equipment	Glove breach	10	Unaware of sharps	9	Worker experience	3	270
Defective or improper handling of expanders and gloves	Glove failure	10	Improper storage of GB gloves	3	Warehouse and controlled storage	6	180

Potential Failure Modes (process defects)	Potential Failure Effects (Ys)	SEV	Potential Causes of Failure (Xs)	OCC	Current Process Controls	DET	RPN
Improper glove inspection	Missed glove breach	10	Complacency	6	Independent organization performs glove inspection	3	180
Improper glove inspection	Missed glove breach	10	Complacency	6	Training for how to inspect	3	180
Improper glove inspection	Missed glove breach	10	Complacency	6	Worker expectation to perform inspection	3	180
Improper glove inspection	Missed glove breach	10	Subjective criteria for glove inspection	6	Training	3	180
Improper glove inspection	Missed glove breach	10	Subjective criteria for glove inspection	6	Procedure	3	180
Improper glove inspection	Missed glove breach	10	Subjective criteria for glove inspection	6	OJT	3	180
Improper glove inspection	Missed glove breach	10	Subjective criteria for glove inspection	6	Worker expectation to perform inspection	3	180
Improper glove inspection	Missed glove breach	10	Different levels of experience	6	Mentoring	3	180
Improper glove inspection	Missed glove breach	10	Different levels of experience	6	OJT	3	180
Improper glove inspection	Missed glove breach	10	Different levels of experience	6	Training	3	180
Improper glove inspection	Missed glove breach	10	Different levels of experience	6	Cold lab training	3	180
Improper glove inspection	Missed glove breach	10	Different levels of experience	6	Worker expectation to perform inspection	3	180
Improper glove inspection	Missed glove breach	10	Rush inspection to get to work	6	Training	3	180
Improper glove inspection	Missed glove breach	10	Rush inspection to get to work	6	Worker expectation to perform inspection	3	180
Improper glove inspection	Missed glove breach	10	Lack understanding of inspection criteria (assumptions about previous person in box)	3	Supervision	6	180
Improper glove inspection	Missed glove breach	10	Vision issues/aging work force	3	Flashlights	6	180
Improper glove inspection	Missed glove breach	10	Vision issues/aging work force	3	Magnifying glasses	6	180
Improper glove inspection	Missed glove breach	10	Vision issues/aging work force	3	LED lights	6	180
Crowded glovebox	Glove breach	10	Maintenance	6	Funding	3	180
Crowded glovebox	Glove breach	10	Large equipment	6	Funding	3	180
Crowded glovebox	Glove breach	10	Number of tools in GB	3	Sharps program	6	180
Crowded glovebox	Glove breach	10	Operator tolerance for work in crowded GB	6	Procedure	3	180
Crowded glovebox	Glove breach	10	Multifunctional GB	6	Combustible limits	3	180
Crowded glovebox	Glove breach	10	Multifunctional GB	6	Procedure	3	180
Inattention	Glove breach	10	Fatigue	6	Time to do work	3	180
Inattention	Glove breach	10	Stress and work priority	3	Supervision	6	180
Poor glove fit	Glove breach	10	Pinch glove	3	Over glove	6	180

Potential Failure Modes (process defects)	Potential Failure Effects (Ys)	SEV	Potential Causes of Failure (Xs)	OCC	Current Process Controls	DET	RPN
Heat sources	Glove breach	10	Rapid oxidation of Pu turnings	3	Over glove	6	180
Heat sources	Glove breach	10	Rapid oxidation of Pu turnings	3	Inert GB	6	180
Heat sources	Glove breach	10	Rapid oxidation of Pu turnings	3	Packaging	6	180
Heat sources	Glove breach	10	Improper glove change frequency	6	GGIP documentation	3	180
Heat sources	Glove breach	10	Glove gets brittle	6	Frequent glove change	3	180
Over aggressive use of glove	Glove breach and degradation	10	Poor process design	3	Supervision	6	180
Over aggressive use of glove	Glove breach and degradation	10	Poor process design	3	Over glove	6	180
Poor glove selection	Glove breach and degradation	10	Slow to make changes to process	3	Supervision	6	180
Poor hand tools	Glove breach	10	Tool slips	3	Replace tools	6	180
Poor hand tools	Glove breach	10	Pick up shard because no hand tool	3	Over glove	6	180
Poor hand tools	Glove breach	10	Pick up shard because no hand tool	3	Tools not available in the box	6	180
Over aggressive use of glove	Glove tear	10	Inattention	6	Training	3	180
Over aggressive use of glove	Glove tear	10	Pressure to do work	3	Supervision	6	180
Over aggressive use of glove	Glove tear	10	Personal style	3	Supervision	6	180
Over aggressive use of glove	Glove tear	10	Personal style	3	Over glove	6	180
Defective or improper handling of expanders and gloves	Glove failure	10	Damage to glove during installation	6	Training	3	180
Defective or improper handling of expanders and gloves	Glove failure	10	Damage to glove during installation	6	Experience	3	180
Defective or improper handling of expanders and gloves	Glove failure	10	Lack of inspection of expander	3	Replacement of expander	6	180
Defective or improper handling of expanders and gloves	Glove failure	10	Burr on the expander	3	Replacement of expander	6	180
Using corrosive chemicals	Glove degradation	10	Process requirement	6	Frequent glove change	3	180
Using corrosive chemicals	Glove degradation	10	Process requirement	6	Training	3	180
Heat sources	Glove degradation	10	Use of furnace	3	Over glove	6	180
Lack scheduled glove change	Glove degradation	10	Perceived time pressures	3	Supervision	6	180
Radiation damage to gloves	Glove degradation	10	Requirement to use rad materials	3	Over glove	6	180
Radiation damage to gloves	Glove degradation	10	Requirement to use rad materials	3	Shielding	6	180
Radiation damage to gloves	Glove degradation	10	Requirement to use rad materials	3	Wipe down gloves	6	180
Using corrosive chemicals	Glove degradation	10	Wrong type of glove for environment	3	Proper glove selection	6	180

Potential Failure Modes (process defects)	Potential Failure Effects (Ys)	SEV	Potential Causes of Failure (Xs)	OCC	Current Process Controls	DET	RPN
Defective or improper handling of expanders and gloves	Glove failure	10	Damage to glove during installation	6	Procedure	3	180
Lack of appropriate gloves in the warehouse	Glove breach	10	Forecasts get lost	3	Glovebox safety program manager to manage GB safety	6	180
Poor GB design	Glove breach	10	Comfortable with current rad protection	6	New predictive rad program for rad coming out of box	3	180
Lack of mentoring process on glove	Glove breach and degradation	10	Improper inspection	6	Training	3	180
Lack of mentoring process on glove	Glove breach and degradation	10	Improper inspection	6	Experience	3	180
Lack of mentoring process on glove	Glove breach and degradation	10	Improper use	6	Training	3	180
Lack of mentoring process on glove	Glove breach and degradation	10	Improper use	6	Experience	3	180
Lack of mentoring process on glove	Glove breach and degradation	10	Improper glove change	6	Training	3	180
Lack of mentoring process on glove	Glove breach and degradation	10	Improper glove change	6	Experience	3	180
Lack of mentoring process on glove	Glove breach and degradation	10	Improper care	6	Training	3	180
Lack of mentoring process on glove	Glove breach and degradation	10	Improper glove change frequency	6	Experience	3	180
Improper glove inspection	Missed glove breach	10	Different levels of experience	6	Procedure	3	180
Inattention	Glove breach	10	Fatigue	6	Breaks	3	180
Poor hand tools	Glove breach	10	Pick up shard because no hand tool	3	Tools required to be in one location per procedure	6	180
Heat sources	Glove degradation	10	Use of furnace	3	Insulation	6	180
Heat sources	Glove degradation	10	Rapid oxidation of Pu turnings	3	Over glove	6	180
Heat sources	Glove degradation	10	Rapid oxidation of Pu turnings	3	Packaging	6	180
Long reach within the GB	Glove tear	10	Lack of funding to involve additional talent	3	Management support	6	180
Inattention	Glove breach	10	Fatigue	6	Tim's gym to work out	3	180
Poor glove fit	Glove breach	10	Pinch glove	3	Over glove	6	180
Improper glove inspection	Missed glove breach	10	Complacency	6	GGIP document calls for daily inspection	3	180
Improper glove inspection	Missed glove breach	10	Subjective criteria for glove inspection	6	Cold lab training	3	180
Machining equipment	Glove breach	10	Not enough space	3	Redesign process, GB, and equipment	6	180
Heat sources	Glove degradation	10	Rapid oxidation of Pu turnings	3	Inert GB	6	180
Improper glove inspection	Missed glove breach	10	Subjective criteria for glove inspection	6	Mentoring	3	180
Defective or improper handling of expanders and gloves	Glove failure	10	Improper storage of GB gloves	3	Experience	3	90

Potential Failure Modes (process defects)	Potential Failure Effects (Ys)	SEV	Potential Causes of Failure (Xs)	OCC	Current Process Controls	DET	RPN
Improper glove inspection	Missed glove breach	10	Lack understanding of inspection criteria (assumptions about previous person in box)	3	Worker expectation to perform inspection	3	90
Improper glove inspection	Missed glove breach	10	Lack understanding of inspection criteria (assumptions about previous person in box)	3	Training	3	90
Improper glove inspection	Missed glove breach	10	Lack understanding of inspection criteria (assumptions about previous person in box)	3	Procedure	3	90
Improper glove inspection	Missed glove breach	10	Lack understanding of inspection criteria (assumptions about previous person in box)	3	OJT	3	90
Improper glove inspection	Missed glove breach	10	Lack understanding of inspection criteria (assumptions about previous person in box)	3	Worker experience	3	90
Improper glove inspection	Missed glove breach	10	Vision issues/aging work force	3	Corrective lenses	3	90
Crowded glovebox	Glove breach	10	Number of tools in GB	3	Combustible limits	3	90
Heat sources	Glove breach	10	Rapid oxidation of Pu turnings	3	Training	3	90
Over aggressive use of glove	Glove breach and degradation	10	Poor process design	3	Training	3	90
Over aggressive use of glove	Glove breach and degradation	10	Poor process design	3	Procedure	3	90
Over aggressive use of glove	Glove tear	10	Pressure to do work	3	Work load management (assignment for tech)	3	90
Defective or improper handling of expanders and gloves	Glove failure	10	Improper storage of expander	3	Experience	3	90
Defective or improper handling of expanders and gloves	Glove failure	10	Improper storage of GB gloves	3	Procedure	3	90
Defective or improper handling of expanders and gloves	Glove failure	10	Improper storage of GB gloves	3	Training	3	90
Heat sources	Glove degradation	10	Rapid oxidation of Pu turnings	3	Training	3	90
Radiation damage to gloves	Glove degradation	10	Requirement to use rad materials	3	Dose surveys of gloves	3	90
Radiation damage to gloves	Glove degradation	10	Requirement to use rad materials	3	Routine glove changes	3	90
Inattention	Glove breach	10	Stress and work priority	3	Work load management (assignment for tech)	3	90
Heat sources	Glove degradation	10	Use of furnace	3	Training	3	90

Potential Failure Modes (process defects)	Potential Failure Effects (Ys)	SEV	Potential Causes of Failure (Xs)	OCC	Current Process Controls	DET	RPN
Lack of appropriate gloves in the warehouse	Glove breach	10	QA inspection detects off spec	3	Entire glove lot is rejected and prevented from being put in service	3	90

FMEA Rating Tool

Rating	Occurrence of the Cause
10	
9	frequent
8	
7	
6	occasional
5	
4	
3	rare
2	
1	

		Prevention of Cause		
Detection of Cause		lo	hi	
	lo	6	3	hi
	hi	9	6	lo

High score is aligned with the opportunity for an improvement

Implementation Plan

Solution	Improvement Action	Solution Owner	Issues/ Barriers	Target/ Actual Complete Date	Current Status/ Comments
Best Practices	List the questions and the focus areas for glove event investigations	Gene Ortega and Vince Garcia	N/A	20-Dec-13	End date
	Implement funding mechanism for when microscopic analysis is performed (Communication issue for the codes)	Judith Eglin		Jan-14	Ongoing
	Address the timeliness of initial investigation	Robert Baran	Glovebox Safety Program is on the RPO notification list	Jan-14	Robert needs to be invited to every RPO critique. Ongoing
	Conduct the investigation in a personal manner without a crowd or managers (above FLM)	Robert Baran	Avoid the perception of witch hunt and blame game	Jan-14	Ongoing
	Incorporate new rules for RCT reporting into the RPO reporting training	Reggie Fuchs	N/A	Mar-14	Start date
	Improve and standardize the investigation process for glove events, the documentation, and communication of the results	Dianne Wilburn/ Howard Granzow	Sensitivity to glovebox workers and the extra burden. Limit time needed from the worker. Robert's time is needed. Microscopic analysis resources needed.	Apr-14	Is TA55-AP-039 the applicable document? Are the annual management assessments (p. 13) conducted? What are the results of the assessments? End date
	Establish process to keep the glove long enough to investigate and then dispose properly update TA55-AP-039	Dianne Wilburn/ Howard Granzow	Perception for combustible limits	Apr-14	TA55-AP-039. End date
	Involve the systems engineers in the glove event investigations and take action to improve tools and equipment	Ops Manager (Chuck Tesch)		Apr-14	Ongoing
	Establish the criteria and process for when microscopic analysis is performed (develop capability in Pu-238 area)	Dianne Wilburn/ Howard Granzow	Resource loading (NCO-2 and MET-1). Clarify disposition of glove after analysis (funding and return to owner). Microscopic analysis is cost prohibitive for Pu-238 and the current location cannot accommodate Pu-238. PFITS recommended	Apr-14	TA55-AP-039. End date
	Assess compliance with TA55-AP-039	Dianne Wilburn		Sep-14	Include with Facility Centered Assessment. End date

Solution	Improvement Action	Solution Owner	Issues/ Barriers	Target/ Actual Complete Date	Current Status/ Comments
	Update TA55-AP-039 with the improved investigation process	Robert Baran		Sep-14	End date
	Correct critiques logged as glove breaches/ failures when they were not	Stanley Trujillo	N/A	Completed 8/14/13	PFITS # 2012-1134, 3345 and 4564
	Provide examples of RPOs not correctly flagging glove breaches and failures	Jackie Hurtle	N/A	Completed 8/14/13	
	Develop new rules for tracking RPOs as glove breaches and failures	Paul Hoover	N/A	Completed 8/14/13	Include suspect breaches and failures. Revisit the RPO entry after investigation is completed and update accordingly
Communication	Present to Bob Mason	Jackie Hurtle	N/A	23-Dec-13	End date
	Ensure the understanding and commitment of actions is transferred to the responsible individuals identified in the implementation plan	Dianne Wilburn		Jan-14	End date
	Present to MRB	Jackie Hurtle		14-Jan-14 at 10 am	End date
	Present to Institutional Radiation Safety Committee	Jackie Hurtle	N/A	31-Jan-14	End date
	Present to Glovebox Safety Committee	Jackie Hurtle	Schedule with Dianne	31-Jan-14	End date
	Present to WSST	Jackie Hurtle	Glenda Bustos	28-Feb-14	End date
	Present to Institutional Glovebox Safety Committee	Jackie Hurtle	Schedule with Dianne	28-Feb-14	End date
	Present to Directorate Employee Safety Council	Jackie Hurtle	Howard Granzow	28-Feb-14	End date
Latent Sharps	Establish the team to develop the enhanced latent sharps screening process	Dianne Wilburn/ Howard Granzow		Feb-14	End date
	Develop process to screen latent sharps	Team effort		Mar-14	Start date
	Document screening process. Update TA55-AP-120	Dianne Wilburn		Apr-14	End date
	Push the latent sharps program across TA-55-PF-4 with awareness and communication	Dianne Wilburn/ Howard Granzow	Management engagement and resources	Apr-14	Start date

Solution	Improvement Action	Solution Owner	Issues/ Barriers	Target/ Actual Complete Date	Current Status/ Comments
	Include the cheesecloth analysis on some established frequency (balance the benefit and the burden)	Dianne Wilburn/ Howard Granzow	Management engagement and resources	Apr-14	End date
	Implement better engineered controls as identified in process	Systems engineer	Funding, time, criticality, and fire constraints. Promote awareness of ideas. Follow-through is at risk	Apr-14	End date
	Consider over gloves for use in additional situations	Team Effort	See below to improve glove fit to enhance dexterity when using over gloves	Apr-14	Ongoing
	Consider the use of leather over gloves	Team Effort	Leather gloves are not in all boxes	Apr-14	Ongoing
	Improve the storage of over gloves	Team Effort	Ease is critical to success. Must be required	Apr-14	Ongoing
	Involve the systems engineers in the team that reviews process for latent sharps and take action to improve tools and equipment	Systems engineers		Apr-14	Ongoing
	Formalize the tracking of latent sharps assessments	Dianne Wilburn		Apr-14	End date
	Establish a team to perform screening	Dianne Wilburn/ Howard Granzow		May-14	Start date
	Review the current process and documentation for latent sharps review (are we complying)	Dianne Wilburn		Sep-14	Recommend an internal assessment of compliance with TA55-AP-120? End date
	Screen all processes for latent sharps	Team effort	Management engagement and resources	Sep-15	End date
Glove Fit and Selection	Offer to work a Black Belt study for the glove forecast process with NPI-8	Jackie Hurtle	NPI-8 interest and availability	23-Dec-13	End date
	Convene and engage a team to create a decision tree for glove selection, inspection and change process based on process hazards and worker anthropometrics	Dianne Wilburn/ Howard Granzow	Management engagement and resources	Feb-14	Start date
	Identify a minimum variety of glovebox gloves (by material and size) to be maintained by the warehouse	Erin Blue		Feb-14	Start date

Solution	Improvement Action	Solution Owner	Issues/ Barriers	Target/ Actual Complete Date	Current Status/ Comments
	Target the rooms with the highest glove fit issues and compare glove hand size and make specific recommendations	Cindy Lawton		Mar-14	End date
	Work with the warehouse to ensure that recommended glovebox gloves are stocked and available	Jackie Hurtle	Limited space and glove shelf life	May-14	End date
	Publish the decision tree	Dianne Wilburn/ Howard Granzow		Jul-14	End date
	Document the decision tree in a DOP	Dianne Wilburn/ Howard Granzow		Aug-14	Is this TA55-AP-039? End date
	Continue the effort to redesign the LANL glovebox glove	Cindy Lawton	Management engagement and resources	Jan-17	End date
Engineered Controls	Continue to support and fund the database development to track glove installation, inspection, and change dates	Dianne Wilburn/ Howard Granzow	Management engagement and resources	Dec-13	Ongoing
	Follow through on critique recommendations, ex. similarities between RPO 4633 and RPO 4838	Chuck Tesch/ Stanley Trujillo	Management engagement and resources	Feb-14	Start date
	Analyze data from the database and report at the glovebox safety committee meetings	Dianne Wilburn	Management engagement and resources	Feb-14	Start date
	Encourage workers to make recommendations for improvement	FLM/ORS	Offer incentives	Mar-14	Start date
	Track engineered changes to promote improvement and share engineering changes	WSST chair	Management engagement and resources	Mar-14	Start date
	Establish a process to pressure check glovebox gloves (depends on the type of box) to identify pinhole leaks that are not visually obvious	FLM/ORS champion, facility ownership	Management engagement and resources	Mar-14	David Wannigman's passion. Rick Hinckley. Start date
	Develop process to inspect new items for approval and entry into the glovebox	Dianne Wilburn/ Howard Granzow/ Tony Drypolcher	Management engagement and resources	Jun-14	End date

Solution	Improvement Action	Solution Owner	Issues/ Barriers	Target/ Actual Complete Date	Current Status/ Comments
	Use glovebox systems engineers to develop engineered solutions in response to glove event investigations and latent sharps reviews	Systems engineers	Management engagement and resources	Aug-14	Ongoing
	Implement new technology - vacuum to collect shards, wringer design for rags, new scales without glass and smaller in size, size reduction of existing equipment (ex. furnace)	Systems engineers	Management engagement and resources	Aug-14	Start date
	Document the pressure check process (preventative maintenance)	Brad Smith		Sep-14	End date
	Assign engineer to track and address glove events with an emphasis for change and prevention (new dedicated job?)	Bob Mason	People wear too many hats	Oct-14	Train with and replace Kirk Veirs on the microscopic analysis. Start date
	Improve ways to transfer material (within box)	GB systems engineers	Management engagement and resources	Dec-14	End date
	Implement new trolley tray design	Gus Dozhier, Tony Drypolcher, Cindy Lawton	Management engagement and resources	Dec-14	David Rael had a new design. End date
Glove Change	Continue the evaluation of glove events and glove changes by CCS-6 to develop recommendations for glove changes by process	Dianne Wilburn/ Howard Granzow	Coordination and funding	Dec-13	Start date
	Document the glove change recommendations	Dianne Wilburn/ Howard Granzow		Oct-14	End date
Project Close Out	Populate recommendations in PFITS or a project management tool to formally track implementation of recommendations	Howard Granzow		31-Jan-14	See shaded actions. End date
	Develop and populate a control chart for the primary metric and transition to the Glovebox Safety Program	Jackie Hurtle		31-Jan-14	
	Update the primary metric	Jackie Hurtle	Opportunity for resumption and implementation	19-Dec-14	End date

Solution	Improvement Action	Solution Owner	Issues/ Barriers	Target/ Actual Complete Date	Current Status/ Comments
	Update the secondary metrics	Jackie Hurtle	Opportunity for resumption and implementation	19-Dec-14	End date
	Update the capability analysis	Jackie Hurtle	Opportunity for resumption and implementation	19-Dec-14	End date
	Perform a statistical test on the glove events to compare performance before and after implementation of recommendations	Jackie Hurtle	Opportunity for resumption and implementation	19-Dec-14	End date

DMAIC Summary

Decrease the Number of Glovebox Glove Breaches and Failures

Define	Between July 2011 and June 2013, TA-55-PF-4 had 65 glovebox glove breaches and failures with an average of 2.7 per month. The current target is one or less per month averaged over time. With 2.7 glovebox glove breaches and failures per month, the cost of poor quality (COPQ) is \$1.5 million per year and includes the cost to investigate and mitigate common contamination events and the loss of facility productivity.
Measure	<p>The factors contributing to glove events that surfaced from the cause and effect tools include the following:</p> <ul style="list-style-type: none"> • Housekeeping in the glovebox • Evaluating the glove inspection and deciding to change the glove • Glove fit • Glove selection tailored to the process and operator • Glove tracking data (for prescribed glove change) • Process specific guidance for when to change gloves related to glove use • The planning process to change gloves is arduous • Managing sharps (perceived inconsistencies in) • Latent sharps program • Mentoring, OJT, cold lab practice, qualified trainer • Human performance • Engineered controls: Perceived value of change is less than the perceived value of using the legacy equipment and tools • Cost estimates for glovebox design and engineered controls are not realistic • Communication between the design team and the glovebox users is lacking and the equipment in the glovebox suffers from poor engineering
Analyze	<p>After some combination of factors, four probable causes were confirmed and they include the following:</p> <ul style="list-style-type: none"> • Failure to identify latent sharps (inadequate identification of hazards) • Improper glove fit and selection • Inadequate use of engineered controls • Lack of timely glove change <p>Three causes were eliminated including human performance and training, non-compliance with the sharps program, and glovebox housekeeping.</p>
Improve	<p>The recommended solutions include the following:</p> <p>Best Practices</p> <ul style="list-style-type: none"> • Improve and standardize the investigation process for glove events • Ensure the implementation of corrective actions from critiques <p>Latent sharps</p> <ul style="list-style-type: none"> • Screen all processes for latent sharps • Implement the cheesecloth analysis on a regular basis

	<ul style="list-style-type: none">• Improve the dexterity of gloves to allow for the use of over gloves Glove fit and selection <ul style="list-style-type: none">• Redesign the glovebox glove• Establish the variety of gloves to be stocked in the warehouse Engineered controls <ul style="list-style-type: none">• Develop a process to review and approve new engineered controls for introduction into gloveboxes• Involve glovebox systems engineers in investigation and corrective actions to inspire new engineered controls• Implement new technology (material transfer, size reduction) Glove change <ul style="list-style-type: none">• Create decision tree for glove selection, inspection, and change• Establish a pressure check method for glovebox gloves to identify breaches before they are visible• Improve glove forecast• Complete statistical study of glove events by process• Improve glove tracking to facilitate a prescribed change schedule																																																
Control	<div>The implementation plan includes actions to inform and engage management and glovebox operators; improve and maintain existing glovebox glove data; record and maintain newly proposed glovebox glove data; improve and standardize the glove event investigations; improve documentation and guidance for glove selection, inspection, and change; improve hazard identification and evaluation process for latent sharps; continue with the glovebox glove redesign; ensure the implementation of recommendations that result from glove event investigations and critiques; develop a process to evaluate and approve new engineered controls for introduction into the gloveboxes; establish a process to pressure check glovebox gloves; and validate the improvements.</div> <div><div>Primary Metric</div><div>Glove Breaches and Failures by Month</div><table><caption>Glove Breaches and Failures by Month Data (Estimated)</caption><thead><tr><th>Month</th><th>Count</th></tr></thead><tbody><tr><td>2011-07</td><td>2</td></tr><tr><td>2011-09</td><td>4</td></tr><tr><td>2011-11</td><td>1</td></tr><tr><td>2012-01</td><td>4</td></tr><tr><td>2012-03</td><td>5</td></tr><tr><td>2012-05</td><td>2</td></tr><tr><td>2012-07</td><td>3</td></tr><tr><td>2012-09</td><td>2</td></tr><tr><td>2012-11</td><td>1</td></tr><tr><td>2013-01</td><td>6</td></tr><tr><td>2013-03</td><td>2</td></tr><tr><td>2013-05</td><td>2</td></tr><tr><td>2013-07</td><td>1</td></tr><tr><td>2013-09</td><td>0</td></tr><tr><td>2013-11</td><td>0</td></tr><tr><td>2014-01</td><td>0</td></tr><tr><td>2014-03</td><td>0</td></tr><tr><td>2014-05</td><td>0</td></tr><tr><td>2014-07</td><td>0</td></tr><tr><td>2014-09</td><td>0</td></tr><tr><td>2014-11</td><td>0</td></tr><tr><td>2015-01</td><td>0</td></tr><tr><td>2015-03</td><td>0</td></tr></tbody></table></div>	Month	Count	2011-07	2	2011-09	4	2011-11	1	2012-01	4	2012-03	5	2012-05	2	2012-07	3	2012-09	2	2012-11	1	2013-01	6	2013-03	2	2013-05	2	2013-07	1	2013-09	0	2013-11	0	2014-01	0	2014-03	0	2014-05	0	2014-07	0	2014-09	0	2014-11	0	2015-01	0	2015-03	0
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Results	Benefits are realized as the number of glove events decline. This study offers suggestions for influencing the factors that contribute to glove events.																																																
Benefits	With each glove event prevented, LANL saves an average of \$23K on the waste disposal and labor associated with the investigation, mitigation, and reporting. Additional savings are expected from the increased productivity of the facility.																																																
The one page DMAIC Summary must be electronically signed by the Belt (GB(c), BB(c), or MBB(c)) that																																																	

conducted the PIP; the Belt that conducted peer review, the Champion (or management sponsor), and the MBB for certification PIPs. Electronic signature is achieved by enter their names (and dates) below:

Jackie Hurtle

Belt Conducting PIP

Date

Robert Harris

Belt Conducting Peer Review

Date

Howard Granzow

Champion

Date

Improvement Summary

Improvement Summary

Project Title:	Decrease the Number of Glovebox Glove Breaches and Failures		
Project Owner (Name & Z#):	Jackie Hurtle, 115611	Champion (Name & Z#):	Howard Granzow, 154445
PAD Acronym (Ex: PADOPS):	PADOPS	AD Acronym (Ex: ADBS):	ADNHOO
DIV Acronym (Ex: ASM):	TA55	Group Acronym (Ex: PM):	DIV
Start Date (estimated is OK):	7/22/13	End Date (estimated is OK):	12/23/13
Is this improvement linked to a LANL Commitment, Goal, or PBI? If yes; which one(s)?			
Not applicable.			
Briefly describe the process that was improved:			
<p>Glovebox work at TA-55 follows the five step safety process promoted at LANL with a decision diamond interjected for whether or not a glove breach or failure event occurred in the course of glovebox work. In the event that no glove breach or failure is detected, there is a decision for whether or not contamination is detected. In the event that contamination is detected, the possibility for a glove breach or failure event is revisited. This project focused on glovebox glove events.</p>			
Briefly describe how the process was changed:			
<p>In general, the recommended solutions include the following:</p> <p>Best Practices</p> <ul style="list-style-type: none"> • Improve and standardize the investigation process for glove events • Ensure the implementation of corrective actions from critiques <p>Latent sharps</p> <ul style="list-style-type: none"> • Screen all processes for latent sharps • Implement the cheesecloth analysis on a regular basis • Improve the dexterity of gloves to allow for the use of over gloves <p>Glove fit and selection</p> <ul style="list-style-type: none"> • Redesign the glovebox glove • Establish the variety of gloves to be stocked in the warehouse <p>Engineered controls</p> <ul style="list-style-type: none"> • Develop a process to review and approve new engineered controls for introduction into gloveboxes • Involve glovebox systems engineers in investigation and corrective actions to inspire new engineered controls • Implement new technology (material transfer, size reduction) <p>Glove change</p> <ul style="list-style-type: none"> • Create decision tree for glove selection, inspection, and change • Establish a pressure check method for glovebox gloves to identify breaches before they are 			

visible

- Improve glove forecast
- Complete statistical study of glove events by process
- Improve glove tracking to facilitate a prescribed change schedule

If this project resulted in A1, A2, or A3 benefits* describe how those benefits were calculated (show your math):

(A type benefits are considered "hard" savings that can be traced through budget increases, reductions, and/or the use of different cost codes.)

Not applicable.

If this project resulted in B1 or B2 benefits* describe how those benefits were calculated (show your math):

(B type benefits are considered "soft" savings and are a theoretical value of the improvement.)

The cost of poor quality associated with investigation and mitigation of common glove events and the loss of facility productivity is estimated at \$1.5 million per year. The objective of this project is to reduce 63% of the glove events for a potential benefit of \$929K per year.

Financial Investment in Improvements

Validation will include a review of the financial investments to implement the recommendations. Estimates are not currently available.

Facility Productivity COPQ Summary

At TA-55-PF-4, a day's loss of productivity is estimated to cost \$1.36 million. Actual facility availability is estimated at 96.38 % based on the first six months of 2013. Based on facility operations data for September 2011 to August 2012, approximately 50% of the unplanned down time is attributed to radioactive contamination. From the Radiation Protection Observation (RPO) system, for all of the radioactivity contamination events at TA-55-PF-4, 15% of the observations involve glovebox glove events. With these estimates, the COPQ for TA-55-PF-4 down time associated with glove events is estimated to be \$716K per year assuming 195 annual work days (the weekly schedule is Monday through Thursday). The calculation for the COPQ of \$716K/yr is shown below.

TA-55-PF-4 COPQ: \$1.36 million/day * 195 days/yr * (100 – 96.38 %) * 0.5 * 0.15 = \$716K/yr

Investigation and Mitigation

The cost of investigation and mitigation for common glove breach and failure events is \$758K per year. This estimate is based on an average of 2.7 common glove breach and failure events per month and an average cost of \$23K per event for the waste disposal and the labor associated with the investigation, mitigation, and reporting. This COPQ is associated with B2 savings, used to produce more of the same scope type. The specific resources and rates are summarized in the following table.

Stage	Activity	Resources	Participants	Hours	Rate (\$/hr)	Cost (\$)	Basis
Investigation	Field investigation	RCT	2	4	\$ 60	\$ 480	Per Event
		GGI Staff	1	8	\$ 98	\$ 784	Per Event
	Management critique	RCT	2	1	\$ 60	\$ 120	Per Event
		Manager	10	1	\$ 144	\$ 1,440	Per Event
		Engineer	5	1	\$ 72	\$ 360	Per Event
Mitigation	Glove Replacement	Operator	4	1	\$ 60	\$ 240	Per Event
		FLM RP Manager 1	1	1	\$ 72	\$ 72	Per Event
		Manufacturing Manager 3	1	0.5	\$ 97	\$ 49	Per Event
		RCT	1	1	\$ 60	\$ 60	Per Event
		New glove	1	-	\$ 400	\$ 400	Per glove
	Work Document Preparation	Operator	2	1	\$ 60	\$ 120	Per Event
		FLM RP manager 1	1	1	\$ 72	\$ 72	Per Event
		Team Leader manager 2	1	1	\$ 95	\$ 95	Per Event
		RCT	1	1	\$ 60	\$ 60	Per Event
	Glove Forensics	Scientist	1	10	\$ 132	\$ 1,320	1/4 Events
	Decontamination	Operator	2	2	\$ 60	\$ 240	Per Event
		RCT	1	2	\$ 60	\$ 120	Per Event
Reporting	Log critique and PFITS actions	Professional	1	1	\$ 72	\$ 72	Per Event
	Entry in RPO system	RCT	1	2.5	\$ 60	\$ 150	Per Event
Waste Disposal	Activity	Resources	Volume	Unit	Rate (\$/unit)	Cost (\$)	Basis
	Liquid waste disposal	Low Level Waste	10	gal	\$ -	\$ -	Per Event
	Solid waste disposal	Low Level Waste	1	M ³	\$ 17,582	\$ 17,582	Per Event
	Mixed TRU waste disposal	TRU Waste	0.208	M ³	\$ 17,500	\$ 17,500	Per Year
					Common event	\$ 22,846	(2.7/mo)
					Periodic cost	\$ 17,500	
					Cost per year	\$ 757,694	
<p>If this project resulted in B3 benefits* briefly describe how those benefits will impact LANL: <i>(B3 benefits have intrinsic value and are not monetized.)</i></p> <p>There is COPQ for the nonmonetary impacts associated with the public perception of poor performance,</p>							

loss of confidence from stakeholders, and potential exposure of workers.

Summarize annual savings below, from the current year & out for the next four years (as appropriate):

Current Year:		2014	First Full Year:		2015	Second Full Year:		2016	Third Full Year:		2017	Fourth Full Year:		N/A
A1	\$		A1	\$		A1	\$		A1	\$		A1	\$	
A2	\$		A2	\$		A2	\$		A2	\$		A2	\$	
A3	\$		A3	\$		A3	\$		A3	\$		A3	\$	
B1	\$		B1	\$		B1	\$		B1	\$		B1	\$	
B2	\$	N/A	B2	\$	\$929K	B2	\$	\$929K	B2	\$	\$929K	B2	\$	\$
Total	\$	N/A	Total	\$	\$929K	Total	\$	\$929K	Total	\$	\$929K	Total	\$	\$

Send copies of this form as follows:

- Your CFO budget analyst or deployed manager should get a copy to validate your financial estimates
- Your PFITs person should get a copy to enter action items or close actions associated with this improvement
- Your line management chain should get a copy so they are aware of the improvement
- Send a copy to improve@lanl.gov to ensure your improvement is logged in the reporting database

To get credit for this improvement in the institutional database (used for reporting to senior management, DOE/LASO, parent organizations, & annual PBI reporting) you must send a copy to improve@lanl.gov!